NATURE

No. 4503 SATURDAY, FEBRUARY 18, 1956 Vol. 177

CONTENTS

	Page
Leadership in a Modern Democracy	293
The Royal Dublin Society. By Sir Nigel Ball, Bart.	295
Advances in Protein Chemistry. By Prof. J. A. V. Butler	295
The Origins of Education. By A. C. F. Beales	296
Developments in Technical Education. By Hugh A. Warren	296
Emulsion Polymerization. By Prof. G. Gee, F.R.S.	297
Electrical Supply Systems in the United States. By G. H. Platt	297
Cinematography in Scientific Research. By Prof. G. E. H. Foxon	298
The Future of Mankind. By Dr. R. E. Slade	298
New Methods in Astronomy. By Dr. J. S. Hey, M.B.E.	299
Reversible, Host-induced, Changes in a Strain of Tobacco Mosaic Virus. By F. C. Bawden, F.R.S.	302
Models for Metallo-enzymes. By Dr. R. J. P. Williams	304
Movements in the Ionosphere. By J. A. Ratcliffe, O.B.E., F.R.S.	307
Obituaries :	
Sir Arthur Trueman, K.B.E., F.R.S. By Prof. Leslie R. Moore	308
Prof. Duncan Leitch. By Dr. J. Weir	309
Sir Richard Redmayne, K.C.B. By Prof. Granville Poole	310
News and Views	311
The Nuffield Foundation : Report for 1954–55	315
Science and Technology in Western Germany	316
Electron Microscopy of Fibres	318
Physics of Atmospheric Clouds. By F. H. Ludlam	320
British Council : Twenty-first Anniversary Report	321
Long Ashton Research Station : Report for 1954. By Dr. John Grainger	322
Relationship between Length of Day and Geotropic Response in Seedlings. By E. Dorothy Brain	323
Spontaneous Chromosome Breakage in Endosperm. By Dr. A. Rutishauser and L. F. La Cour	324
Letters to the Editors :	
Dimorphism of Polyglycine.—Dr. A. B. Meggy and Dr. J. Sikorski	326
Temperature Effects in the Paper Partition Chromatography of Sugars.—Margaret Alcock and J. S. Cannell	327
Bacterial Degradation of Nicotinic Acid.—Isaac Harary	328
Preparation of Antiglobulin Sera.—F. Milgrom, T. Luszczynski and S. Dubiski	329
Metabolism of Sorbitol.—L. H. Adcock and Prof. C. H. Gray	329
Antenatal Sex Determination.—Dr. Fritz Fuchs and Dr. Povl Riis	330
Effect of ββ-Methylethyl Glutarimide and Amytal on Rat-liver Mitochondrial Respiration.—Prof. O. Jalling	330
Remission of Rat Lymphocytic Leukæmia 8 following Intravenous Administration of 4-(p-Diethylaminostyryl)-quinoline Dihydrochloride.—Dr. Boland Hughes, Margaret Reed Lewis and Aubrey L. Bates	331
Responses of Domestic Animals to Infections of *Trypanosoma vivax*, *T. congolense* and *T. brucei*.—Prof. E. E. Edwards, J. M. Judd and F. A. Squire	332
5-Hydroxytryptamine in Serum.—D. F. Sharman and Frank M. Sullivan	332
Phosphorylation as a Possible Factor in the Pasteur Effect in Plants.—Dr. K. S. Rowan, Dr. D. E. Seaman and Prof. J. S. Turner	333
Tripping, Crossing and Selfing in Lucerne Strains.—A. Zaleski	334
Fixity in Chromosome Number of Plants.—Arun Kumar Sharma and Archana Sharma (*née* Mookerjea)	335
Some Problems associated with determining Iron in Plants.—Dr. D. J. D. Nicholas, C. P. Lloyd-Jones and D. J. Fisher	336
A New Type of Male Fructification referable to *Glossopteris*.—J. Sen	337
Effects of Cyanide on the Roots of *Vicia faba*.—Lorna J. Lilly and Dr. J. M. Thoday	338
Living and Fossil Pollen from Macquarie Island.—John Bunt	339
A Direct Method for the Measurement of Cerebral Blood-flow.—D. H. Ingvar and U. Söderberg	339
Action Potentials from Internal Laryngeal Muscles during Phonation.—K. Faaborg-Andersen and Dr. Fritz Buchthal	340
Role of the Terminal Pigment Spots of the Starfish, *Asterias forbesi*, in Light Orientation.—Prof. M. Rockstein	341
Failure of Enforced Hibernation to Inhibit Breeding in the Frog (*Rana temporaria*).—Dr. Rhoda M. Allison	342
Status of *Protobatrachus massinoti*.—I. Griffiths	342
Effect of Supplementary Choline and Methionine on the Response of Chickens to Folic Acid.—M. W. McDonald	343
Science Babel.—Dr. Knut Fægri	343

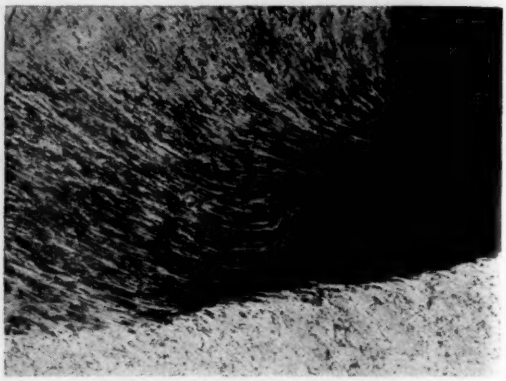
PHOTOGRAPHY AT WORK

—proving that standard practice is not always best practice

Standard practice in the production of blanked metal parts was to use a die with a sharp edge.

But the Production Engineering Research Association were not satisfied that this was the *best* practice. So they put photography to work —to get the facts.

Using the 'Kodak' 0.250 Plate*, PERA carried out controlled research. They made photomicrographs of the results of tests on various pieces of metal—and these photomicrographs proved that metal parts blanked with a round-edged die, with appropriate clearance between punch and die, were of better quality than those made with a sharp-edged die.



Photomicrograph showing deformation of metal when blanked with a sharp-edged die.

— *By courtesy of the Production Engineering Research Association.*

* *Sensitivity of the 'Kodak' 0.250 Rapid Orthochromatic Metallographic Plate is highest in the region of maximum visual sensitivity, where most microscopes yield sharpest focus. This is only one of the reasons why it is preferred by research workers. Let us send you Kodak Data Sheet PL-11, which gives full details.*

Kodak LIMITED

INDUSTRIAL SALES DIVISION

KODAK HOUSE, KINGSWAY, LONDON, W.C.2

'Kodak' is a registered trade-mark

The VIBRON

A British achievement!

The Vibron Electrometer is a new instrument for measuring, with exceptional stability, very small currents from a high impedance source.

The 'heart' of the instrument is the E.I.L. VIBRON vibrating condenser unit, a precise electro-mechanical device which performs some 50 times better than the conventional electrometer valve.

The Vibron Electrometer is being used for ionisation current measurements, as an ultra stable pH meter and as a very high resistance megohmmeter.

Manufactured under British Patent No. 550610 and Patent Application No. 35637/54

Developed and marketed exclusively by:

ELECTRONIC INSTRUMENTS LTD · RICHMOND · SURREY · ENGLAND

E2A

LEADERSHIP IN A MODERN DEMOCRACY

IN his autobiographical volume "Power and Influence", Lord Beveridge says he used to impress on his students at the London School of Economics and Political Science that science and practical reform call ultimately for different qualities and cannot always be served together; and he does not think that the exploration of new fields of thought and administrative work go well together. He commented that the Civil Service can be impartial, but Members of Parliament can be neither impartial nor scientific.

One may indeed challenge Lord Beveridge's view that those who spend their whole lives in scientific work tend to become unpractical or indecisive, whereas those who devote their whole energies to advocating particular measures of practical reform tend to become unscientific; at the same time we can maintain with Smuts (in his Sidgwick Memorial Lecture on "Democracy") that we need to find more effective means of making use of impartial expert opinion, so that decisions are taken with regard to the facts of the situation rather than to prejudice or passion. It remains true, however, that the statesman and politician must have regard to what is politically practicable as well as to what is technically feasible. Expediency is a principle which no one with claims to statesmanship can ignore, whether or not we concede that expediency, and expediency alone, is the basis of all government as the first Earl of Lytton maintained.

For that reason alone the relations between theory and practice in politics are infinitely more complex than Mr. W. Esslinger has suggested in his recent book*. That the university can make an important contribution to the study of politics is not in dispute. It has been urged, for example, by such authorities as Sir Ernest Barker and by his successor in the chair of political science at Cambridge, Prof. D. W. Brogan, as well as by Prof. K. C. Wheare at Oxford. Prof. Brogan sees the study of politics as the study of the means whereby liberty and authority may be best combined, and the dignity of the free man is made compatible with the highest and richest forms of co-operation. Nevertheless, he doubts whether politics can be, in any but the most special sense, a science; and it may be suspected that neither he nor Prof. Wheare would dissent from Lord Beveridge's view as to the impracticability of combining the service of social and political science and the practice of the arts of democratic government in one person.

What Prof. Brogan claimed in his inaugural lecture was that by its study of politics the university could, as Sir Ernest Barker urged in another connexion, "enlist the effective thought of the whole community in the operation of discussion". The ten years since this lecture was delivered have increased our need for strengthening the power of discussion, for broadening civic intelligence and for extending civic knowledge; nor are we using the new means and opportunities of doing so even to the extent necessary to counterbalance the decay of former means of public discussion. We are indeed increasingly better equipped to understand society and mankind, and better able to study society and man and the institutions, traditions and historical conditions that limit and constrain purely political activity than any earlier age; and Prof. Brogan frankly claimed then that the teacher and student of politics in the university has the duty in his teaching and writing of imparting in this double activity as much as possible of the standards of university teaching and research. When, moreover, he continued that the university contribution to politics must often take the form of developing new and deeper understanding of old truths, he came very close to the thesis which Mr. Esslinger expounds.

Arguing for the necessity and possibility of a practical science of politics, Mr. Esslinger suggests that our predicament to-day arises primarily from our lack of rapid adaptation to the swift advances of science and technology and to the loss of our belief in the certainty of progress: we need, he suggests, a practical science of politics from which a political technology can be derived; but the difference between the two is never explained. Though he recognizes that education must cultivate the scientific spirit and that what matters is the scientific attitude, his argument is not made clearer when he gives fresh currency to the term 'sciencing' which L. A. White coined before the War. The term is never defined, nor does Mr. Esslinger ever appear to attach any meaning to it that would justify such a monstrosity.

Mr. Esslinger contributes, in fact, very little to the discussion as to how best we can improve the prospects of obtaining political actions determined more by the facts of the situation than by the prejudices of particular parties or groups, or by traditions which are no longer relevant. Nevertheless, when his counsel is not clouded by jargon, his views do not appear to be widely different from those of Barker, of Wheare or of Brogan, for example. The task of the scientist, as he sees it, is to reconsider the old points of difference and by creative and imaginative thinking indicate new solutions. He admits that there can never be the same accuracy as in the physical sciences; we cannot artificially create and reproduce the conditions of a social or economic process, nor can we even be sure that what works in a small community will work also in the whole State. A knowledge of interrelations and facts provides, none the less, the basis of good judgment, and the power of judgment can be trained in politics as in other fields.

Mr. Esslinger's plea, in fact, seems to amount in essence to one that the universities should broaden

* Politics and Science. By William Esslinger. Pp. xi+167. (New York: Philosophical Library, 1955.) 3 dollars.

the field of studies devoted to practical problems, and in discussing schools of politics he seems to be advocating essentially what Prof. Brogan did in his inaugural lecture at Cambridge; it is to the spread of the scientific outlook and the scientific approach to the problems of government that he looks for the preservation of mankind in this age of nuclear power. The inherent difficulties in any approach to world government lie outside the scope of his book, though his final chapter is an analysis of the reasons for the failure of the League of Nations; he insists that the continuance of civilization depends on our concentrating on and finding solutions for the great political problems of peace, employment, the improvement of the standard of living in backward countries and the rejuvenation of democracy.

It is in this connexion that he has a penetrating chapter on publication facilities, in which he emphasizes the importance of public discussion in testing the validity of new ideas and that this is even more important in respect of constructive thinking than of fact finding. This plea for better facilities for the publication and discussion of ideas is not to be dismissed lightly. It finds some support in the discussion on research in the social sciences arranged by the Parliamentary and Scientific Committee on December 13, 1955, and in passages in the paper, "The Intellectual Individual in Contemporary Society", which Mr. N. G. Fisher, formerly chief education officer for Manchester, read before the Manchester Literary and Philosophical Society last April and which has now been published in the Society's *Memoirs*.

Mr. Fisher, while agreeing that systematic training in orderly methods of thought is indispensable for administration, points out that the practical man must learn the limits of order and system when applied to human affairs, and that illusions accumulate around the intellectual approach to administration. Society works by processes largely spontaneous, seldom predictable and always untidy, and there is a law of compensation in human affairs which determines that nothing is ever as radically good or bad as it is intended and ought to be. On the whole, intellectuals make bad politicians, and politicians make bad intellectuals.

Mr. Fisher would have intellectuals critical of their society; but his lecture offers cold comfort to those who look for the spread of reason or science into public administration and world government. Nor is optimism encouraged by the passage by Keynes on his contemporaries in "Two Memoirs" which he quotes: "We were not aware that civilization was a thin and precarious crust created by the personality and will of a very few and only maintained by rules and conventions skilfully put across and guilefully preserved. We had no respect for the traditional wisdom or the restraints of custom. . . . It did not occur to us to respect the extraordinary achievements of our predecessors in the ordering of life (as it now seems to me to have been) or the elaborate framework which they had devised to protect this order".

Mr. Fisher is no more encouraging as to the value of improved means of communication, though here he is somewhat contradictory. Criticism he admits as a form of leadership, if free of personal animus and divorced from emotional compensations. Clearly he distrusts the intellectual generally in this respect, for he refers in conclusion to the danger that the masses may take the intellectual too seriously.

Where then shall we look for leadership, and how can we hope for public policy to pay the regard to technical advance that is essential if mankind is to continue? There is more hope to be found in the approach indicated by those who took part in a discussion before the Parliamentary and Scientific Committee. Prof. James Drever, who introduced the discussion, was confident that the various social sciences can contribute to the solution of problems set by race relations and international tensions, as well as by school and family and industry. Prof. R. W. Russell maintained that information about the behaviour of man as an individual and as a member of a social group is to-day put to more uses than ever before. Developments in psychological knowledge and technique have enabled the psychologist, with other biological and social scientists, to contribute increasingly, both as scientist and technologist, to the satisfaction of the growing demand for such information. As a scientist the psychologist is concerned with developing a coherent body of knowledge, consisting of general principles underlying behaviour; as a technologist he is concerned with solving problems arising mainly in the public services and in industry.

Prof. Russell thought that solutions to problems of human relations will increasingly be achieved on the basis of knowledge rather than of chance. Prof. T. S. Simey, who spoke as a sociologist, was concerned solely with problems of organization, and emphasized the importance of research in this field being independent politically, free from ideological strings and entirely above suspicion. A university department has an inherent advantage accordingly in organizing such research, so that the integrity of the research worker is established. It is also essential that the objectives of the work should be generally accepted as practical and desirable, and that there should be freedom to make mistakes.

This discussion before the Parliamentary and Scientific Committee went some way to promote the public understanding which is essential if effective work is to be done in the political or social sciences. Such understanding is indispensable for adequate finance to be forthcoming and research maintained on an adequate scale over a term of years, and it can assist also the recruitment of the right type of staff on which Prof. Simey laid stress. Our best hope of advance and of the increasing penetration of the scientific outlook and method into public affairs lies in education—in scientists themselves making the fullest and most effective use of whatever opportunities discussions such as this may offer, or meetings of the British Association, or the Press or radio. It depends, too, on the way in which we tackle the problem of general education not merely of the scientist himself but also of the arts graduate, and at the technical college and in the schools as well as at

the university. It is linked up with the problem of adult and further education in general. Spectacular advance is not to be expected; but the patient, determined and sustained pursuit of public education by all such means offers the surest hope of bringing the grave issues of public policy to-day to a level of public understanding in which they can be handled with reason rather than with passion and prejudice.

THE ROYAL DUBLIN SOCIETY

The Story of the Royal Dublin Society

By Terence de Vere White. Pp. vii+228+13 plates. (Tralee: The Kerryman Limited, 1955.) 21*s*.

THE eighteenth century in Ireland was a period of contrasts. While the existence of wealth and culture was evident in Dublin and the larger towns, poverty and ignorance were widespread. Such was the situation when a small band of enthusiasts met together in 1731 and founded "The Dublin Society for improving Husbandry, Manufactures and other Useful Arts and Sciences". As the author of this book, Mr. Terence de Vere White, points out, each of the founders of the Society was expected by the rules to make a study of some special subject and to report to the Society any relevant information he could obtain by reading, conversation or his own experiments.

The Society, later known as the Royal Dublin Society, has had a chequered history, and many of those who know only of the way it has developed during recent years will be grateful to Mr. White for the interesting account he has produced. The story he tells is largely that of the various men who have played a part in building up the Society during the past two hundred years. Such a treatment makes easy reading, but some of the more irrelevant biographical details might well have been replaced by a fuller account of the work which was done. Scientific activities, especially, receive less attention than they deserve. Throughout its career the Society has given direct support to scientific projects likely to be of benefit to the country, one of the most notable of which was the Radium Institute it established at the instigation of the late Prof. John Joly. In addition, it has helped in the advancement of science in Ireland by holding regular meetings which bring together scientific workers from the universities and other institutions, the papers read at these meetings being afterwards published by the Society. In earlier days it appears that this form of activity was thought to overlap that of the Royal Irish Academy, and an interesting account is given of the brief and indecisive struggle for supremacy which occurred between these two learned bodies some seventy years ago. Mention is also made of the controversy aroused by the proposal, strongly supported by the physicist, G. F. FitzGerald, that the Society should grant fellowships.

However, the promotion of scientific research is but a part of the activity of the Royal Dublin Society and is probably of little direct interest to the majority of its members. The increasing popularity of the Spring Show, and especially of the annual Horse Show, has brought unwonted prosperity. This has enabled the Society to improve its amenities and attract a record membership. It has also served to emphasize the advantages available to an organization which can pull up on the swings what it loses on the roundabouts. One is tempted to speculate what would have happened if men with large ideas had not come forward when they did to found the Dublin Society. The growing tendency to specialization would most likely have led to the founding of smaller bodies, and while some of these would have been successful, others might have wilted through lack of support. As it was, the widely extending roots of the Dublin Society enabled it to expand freely in various directions. Branches such as museums, a botanic garden, an art school and a veterinary college grew out and later became separated from the main stem. The remaining branches continued to give each other nourishment and support. Such an organization has needed a long time for its development, and the story Mr. White recounts was worth telling.

N. G. BALL

ADVANCES IN PROTEIN CHEMISTRY

Advances in Protein Chemistry

Edited by M. L. Anson, Kenneth Bailey and John T. Edsall. Vol. 9. Pp. viii+542. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1954.) 10.50 dollars.

THIS volume maintains the high standard of its predecessors, and like them is so varied as to contain something of interest to most students of proteins. The biochemists will enjoy the article by H. R. V. Arnstein on the metabolism of glycine. As the simplest amino-acid, it enters into many synthetic and degradative reactions, besides its role in protein synthesis, and Dr. Arnstein's article contains a wealth of information on all aspects. M. I. Chalmers and R. L. M. Synge discuss the digestion of proteins and nitrogenous compounds in ruminants—a not unimportant subject, as much of our protein reaches us from the plant via the rumen. The article recalls war-time attempts to utilize the synthetic powers of the ruminant by feeding urea; but the authors conclude that there has been little evolutionary pressure towards an economical use of protein under generous feeding conditions.

The article on the formation, composition and properties of the keratins, by W. H. Ward and H. P. Lundgren, will be of interest both to protein chemists, because their fibre-like nature and great stability make them excellent materials for physical studies, and to technologists, because of the great importance of the wool and leather industries. The basic knowledge of these materials is fully reviewed. S. I. Mizushima reviews the molecular structure of some dipeptides and synthetic polypeptides mainly from the point of view of structure and physical properties. M. Laskowski and M. Laskowski, jun., discuss trypsin inhibitors, and J. P. Greenstein the resolution of racemic α-amino-acids. The remaining articles are more physico-chemical in character. D. F. Waugh's discussion of protein–protein interactions is extremely wide, and includes much information on protein structure and on the changes which particular proteins undergo when treated with various reagents; it also discusses a number of specific types of interactions, for example, antigen–antibody and enzyme–substrate.

Finally, D. F. Cheeseman and J. T. Davies discuss physico-chemical and biological aspects of proteins at

interfaces. On the whole, the study of proteins spread as films at interfaces has been disappointing since, as these authors point out, the specific properties are lost when unfolding takes place. The method on the whole has thrown little light on protein specificity or size, but the authors are able to deduce some interesting reactions of drugs and growth regulators.

J. A. V. Butler

THE ORIGINS OF EDUCATION

Ancient Education

By Prof. William A. Smith. Pp. xii+309. (New York: Philosophical Library, 1955.) 3.75 dollars.

PROF. WILLIAM A. SMITH might well have lost would-be readers by his turgid preface. "Since education is a broad concept," he says, "a concept the connotation of which ranges all the way from the total socialisation process operative in a society to formally organised institutional programs, its scope for historical treatment must of necessity be delimited." There are twelve abstracts in those lines. But his book is, in fact, altogether stimulating. The enormous field he has to cover, in surveying the great civilizations of the ancient world, makes for speed and directness and thereby saves him willy-nilly from overmuch technical jargon. Furthermore, his pages read all the more smoothly for being very systematic. One knows precisely where one is the whole time.

A book on ancient education was long overdue, for the treatment in the standard histories of education at large has rarely yet been more than merely tantalizing. Nor have all these standard histories been quite clear as to how far 'education' means the same when they are looking at Ancient Sumer as when they are on the main highroad with Plato's Academy or Medieval Scholasticism or the Charity Schools. Here Prof. Smith speaks from strength. By education he means something both wider and deeper than "the formal school tradition" of a civilization: deeper, because in fact more than half his study of each great age is devoted to its cultural pattern, rooted in its religion, writing-system and habitat; and wider, because his focus is as follows: "Formal education arose initially to supply *training for specialists*—scribes, priests, accountants. These functionaries arose with the *urban revolution*, and were indispensable in connection with the administration of the *economic surplus*" (p. 129; italics mine). This general thesis he sustains in his first chapter, on the "Grand Divisions of Cultural History", which is certainly a fascinating build-up from the Lower Palæolithic families by way of the "Neolithic revolution" into urban centres needing specialization of function and therefore formal education (the whole transition illustrated archæologically in Mesopotamia).

The great peoples then surveyed are those of Mesopotamia, Ancient Egypt, Ancient India, Ancient China, Greece, Rome and the Hebrews—with a concluding chapter on anthropologically primitive societies to-day as living witnesses of the 'non-literate' stage. The pace is fast, and the narrative a deft outline. One is not sure whether the book is primarily for the reader knowing nothing of the matter until he comes to it, or the student needing revision and a refresher. Certainly both will find in it plenty of great value. At times there is masterly summarization; as, for example, that on Aristotle: "The forms as such do not change, but matter is constantly taking on new forms; hence the sensible world is perpetually changing, and as it does so new forms are realising their potentialities or purposes". But there is equally too much sheer repetition, and too much of "as *X* states", or (oftener) "stresses", or (most of all) "aptly puts it". These quirks are the more irritating since the author can be really profound and graceful when he takes the trouble: for example, in explaining how and why the educational contribution of the Greeks towers above that of contemporary teachers in India and China. "The Indians (Aryas), initially a jolly and extroverted people, early fell under the sway of a sacred literature and a tyrannical priesthood. The Chinese escaped the sacred and the priestly, but succumbed to the past. . . . By way of contrast, the Greeks had no sacred book, no priestly hierarchy, and no authoritarian tradition to keep them from speculating about the nature of man and the world. Their geniuses were, therefore, relatively free. . . ."

That is good writing; and in this book by the former professor of education in the University of California, which makes no claim to great originality and is based on a massive bibliography of already-published studies, there is much like it.

A. C. F. Beales

DEVELOPMENTS IN TECHNICAL EDUCATION

Technical Education

Its Aims, Organisation and Future Development. By Dr. P. F. R. Venables, with five chapters by Specialist Authors. Pp. xii+645. (London: G. Bell and Sons, Ltd., 1955.) 42*s*. net.

"THOUGH technical education is but a small sector of the whole field of education, it nevertheless has a lasting significance in meeting the economic needs of the country through industry and commerce, and in the importance that work and education for work must always have in the individual lives of innumerable people." In these words, Dr. P. F. R. Venables in his preface succinctly states the case for a wider understanding, on the part of both the public and experts, of this field of education.

It is surprising that during the past twenty-five years only one other major volume has been published on the work of technical colleges; although innumerable reports, journals and conferences have dealt with special aspects of technical education. It is therefore most timely that this very comprehensive and authoritative work should appear in print in the same year as Parliament has sanctioned the creation of a diploma in technology and a national council to control the award of that degree-level qualification.

The whole volume comprises twenty chapters: introduction; the colleges; the courses; co-operative partnerships; liaison with industry; selection and placement; seven specialist chapters on selected industries or studies; higher technological education; finance and administration; students' problems; staffing; buildings; and prospect. There are also copious statistical appendixes, a subject index and a name index. Each chapter is very fully annotated by references to a bibliography, and there are many diagrams and graphs illustrating the text.

Any critical appreciation of the volume must depend upon the type of reader for whom the work is intended. It is doubtful whether anyone outside the boundaries of technical education, including the youth employment service and industrial training officers, would have either the understanding or the patience to comb through the mass of information and statistics presented to ascertain just how or why a technical education should be beneficial to his son or daughter. In that respect, the present work differs markedly from a similar volume on technical education recently published abroad in that it includes no photographic illustrations to stimulate imagination or to lighten the heavy going of text and tables.

For those who are directly concerned with technical education, however, this publication is invaluable: as a summary of the present state of technical education; as a mine of statistical information; and as a fairly stated point of view on present problems and on proposed future development. On this last-named point, however, it is noteworthy that although five specialist co-authors were called in, these and the main author are all without exception principals of colleges. The outlook of the class-teacher, the governor and councillor, the education officer, the regional council secretary, the youth employment officer, and of the industrial training executive are thus perforce excluded, or stated at second hand. At first sight, it may seem regrettable that the idea of "partnerships in technical education" so eloquently extolled in Chapter 5—"Running through all are three essentials, administrative, industrial and academic, and all must be preserved in balance if satisfactory harmonious progress is to be made"—could not have been given practical expression in the compilation of this most comprehensive work. No reader of this book, however, more especially Dr. Venables's colleagues in technical education, will fail to be impressed by the immense task of authorship undertaken by him; nor to be grateful that, for a very reasonable price, a handbook of present-day technical education can be placed upon one's desk for day-to-day reference—for the first time since the War.

This treatise can therefore be warmly recommended to teacher, administrator and industrial training officer alike. It should also, by the synthesis it alone provides, do a great deal to place technical education in the forefront of progress.

HUGH A. WARREN

EMULSION POLYMERIZATION

Emulsion Polymerization

By Frank A. Bovey, I. M. Kolthoff, A. I. Medalia and E. J. Meehan. (High Polymers: a Series of Monographs on the Chemistry, Physics and Technology of High Polymeric Substances—Vol. 9.) Pp. xii+445. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1955.) 12.50 dollars.

SINCE emulsion polymerization was first described some thirty years ago, it has attracted a great deal of attention, and it has been found that emulsion polymers may differ very significantly in properties from their counterparts made in other ways. Much of our present understanding of this process arose from the massive effort devoted in the United States during the Second World War to the development of a synthetic rubber industry. The authors of the book under review were intimately involved in the fundamental research programmes associated with that effort, and write from a broad background of knowledge of the polymer field.

The specific problems of emulsion polymerization cannot even be formulated without an understanding of the process of polymerization in simpler systems. The authors might well have assumed their readers to possess such knowledge, or left them to acquire it from other available sources. Instead, they have chosen to make the book essentially self-contained. Following an introductory chapter, the next three chapters outline a treatment of free-radical polymerization which for the most part is not restricted in its application to emulsions. Chapter 5 gives an account of the properties of soap solutions and their ability to solubilize organic liquids, and thus leads up to Chapter 6, which discusses in detail the kinetics of emulsion polymerization. Following a general chapter on inhibitors, the authors turn to copolymerization, and show how normal copolymerization may be modified when the reaction is carried out in emulsion. A chapter on experimental methods includes a brief review of molecular weight procedures, while the final two chapters give a rather full account of the various systems used for the production of the American synthetic rubber *GR—S*.

This is a most interesting and very well-written book, and will be widely welcomed for its connected account of the problems of emulsion polymerization. Because of the plan adopted, the title scarcely does the book justice: it could fairly be described as a general text-book of polymerization, with special reference to the problems of emulsion polymerization. The general sections of the book are of the same high standard as the more specific, and can be confidently recommended as an excellent introduction to the subject. The book is indeed one which might well be put into the hands of students were it not for its unfortunately high price.

G. GEE

ELECTRICAL SUPPLY SYSTEMS IN THE UNITED STATES

Electrical Transmission and Distribution

Edited by Bernhardt G. A. Skrotzki. (Electric Utility Library.) Pp. ix+448. (London: McGraw-Hill Publishing Company, Ltd., 1954.) 56*s*. 6*d*.

MANY good books have been written on the subjects of the generation and mains transmission of electrical energy, but the equally important one of distribution is possibly less well covered. In this volume it is pleasing to find the subject dealt with fully and in considerable detail. Written in an informal style, the book deals exclusively with practice in the United States, but British engineers will find much to interest them therein on this account. The treatment is more descriptive and practical than purely theoretical, and is written for those on the supply side rather than from the point of view of the designer of equipment. An introductory chapter deals with elementary electrical theory so far as is needed for the subsequent treatment.

The major part of the work is devoted to distribution systems, starting with a chapter on

mechanical aspects, including formulæ and calculations for poles and conductors, and concluding with some useful information on cables. Electrical characteristics are next treated, including voltage-drop calculations and descriptions of system arrangements and voltage-regulation methods and apparatus. In this connexion it is interesting to note the wide use made in the United States of single-phase three-wire supply, a system practically unknown in Britain. The use of capacitors for the improvement of the power factor is given most of a chapter to itself, while another one is devoted to protection, including examples of short-circuit calculations. Another chapter is devoted to load characteristics. Diversity and coincidence, problems of varying load, and planning for possible future load-expansion are all dealt with adequately.

Apart from the distribution aspect, there is a short section on transmission, in which overhead lines and cables are described with some useful figures and much practical information. Included also are accounts, mainly descriptive, of transmission switchgear and miscellaneous apparatus—rectifiers, frequency changers, etc.—together with a section on street lighting which makes interesting reading on account of the wide use of the series system in the United States.

The book can be recommended to those interested in the supply industry on the distribution side, and for general reading to university engineering and advanced technical students. G. H. Platt

CINEMATOGRAPHY IN SCIENTIFIC RESEARCH

Research Films in Biology, Anthropology, Psychology and Medicine

By Anthony R. Michaelis. Pp. xvi+490. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1955.) 10 dollars.

CINEMATOGRAPHY has been, and is, used by scientists for a number of different purposes. First, a film may be used as a method of illustration in teaching; secondly, it may be used for recording and demonstrating methods and techniques used in research; and thirdly, cinematography can be used as a research method in its own right. Obviously, such a classification cannot be hard and fast, for a fact discovered by cinematography often finds its way into a teaching film; indeed, it would be strange if it did not. But it is primarily with the last of the three categories of film just mentioned that Dr. Michaelis treats.

In this most comprehensive book are reviewed the origin and development of cinematographic methods used in the study of the sciences listed in its title. In this wide field it is not surprising that the number of techniques is large and that the descriptions of them are widely scattered, both in journals devoted to scientific photography and in the journals of the various specialities. Dr. Michaelis, himself a scientific cinematographer of distinction, has set out to review this field and to provide those who are interested in the subject with an authoritative survey.

The large amount of information which Dr. Michaelis has gathered presents its own problems when it comes to be marshalled for the instruction of the reader. The author's method has been to give a general introduction dealing with definitions of cinematography and research films, with the early history of research films, and then to deal with those points which may be considered as general to all the sciences under review. These sciences are then considered in turn, being divided into biological, human and medical science. In each section Dr. Michaelis explains how cinematography can best be used in that subject and goes on to describe the relevant special methods and concludes with a review of the use to which the research film has been put. In some instances he makes suggestions as to further research by such methods.

This book, therefore, is of value not only as presenting a summary of the methods of cinematography in research, but also as a history of research films.

It is possible to suggest that perhaps these two aspects of history and method have not been sufficiently separated to enable the reader primarily interested in methods to refer to them without having to read a rather too large amount of history also. To this it might well be replied that the development of methods is a matter of history and also that, in order to judge whether any one method is likely to be useful, it is as well to know the kind of result that has already been obtained by its use. However, the reader who wishes to use this book mainly as a source of methods is well catered for with an adequate subject index and also an author and reference index which includes some 1,490 entries.

Dr. Michaelis is to be congratulated on having produced a book which is a significant contribution to the history of cinematography and which also can be confidently recommended for the library of any laboratory in which studies using cinematographic methods are likely to be undertaken. It is well produced, and the misprints which seem inevitable in first editions are few. G. E. H. Foxon

THE FUTURE OF MANKIND

Two Ears of Corn, Two Blades of Grass

By D. H. Killeffer. Pp. x+139+36 plates. (New York: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1955.) 30*s*. net.

ABOUT a hundred and fifty years ago Malthus saw, in his own village, that the limit to the increase in population was determined by the quantity of food available. He suggested that life would be easier if man could adjust his rate of increase to the amount of food available. But the industrial revolution, with improvements in agriculture and transport by land and sea, made it so much easier to obtain food that during the next hundred years the population of Britain increased fourfold and there seemed to be no limit to our food supply. The difficulties of obtaining food during world wars have, however, made us think again about this problem of population and food supply.

Sir Charles Darwin in "The Next Million Years" (1953) concluded that "In the very long run of a million years the general course of future history is, most of the time, likely to be what it has been for most of past time, a continual pressure of population on its means of subsistence—with a margin of the population unable to survive".

Mr. Killeffer's book contains an account of the scientific and technical developments of the chemical and associated industries in the United States during the past thirty years. He writes with a good inside knowledge of his subject, and every paragraph reflects the optimism which is behind the growth of industries in his country. He reviews the industries producing drugs, antibiotics, chemicals from petroleum, synthetic rubber, vitamins, chemicals for the protection of crops from insects, weeds and fungi, atomic energy and radioactive isotopes, plastics and metals.

Then he considers the problems of the future. He has no fear that the growth of population in the world will ever lead to famine because "American Technologies are going to other countries for nationals there to develop and utilize". He explains that we shall never be short of metals, sources of energy to work our factories, or food. First there will be great advances in agriculture by improving both the intensity and extent of cultivation and fertilization of our fields. But eventually we shall produce our protein foods in factories by growing yeasts and moulds. But we may have to grow our sugars and carbohydrates on farm land where we can utilize the energy of the sun. He considers that "We already know how to live well even when fields and farms shrink. Centuries before we will need them for that purpose, our industry is already operating processes that will free us from the necessity of farming fields for food. We can properly put our fears in a deep freezer".

Mr. Killeffer believes that the social and political effects will be that "Universal peace can be easily and surely realized by applying technology and science through human co-operation and collaboration to solve the basic human problems of nutrition, health and resources. We already know how to produce plenty of food and how to free people from the fear of hunger and from the load that sickness, disease and misery lay upon them. We can overcome these terrors if we apply throughout the world the techniques that we already know".

R. E. Slade

NEW METHODS IN ASTRONOMY

Radio Astronomy

By Dr. J. L. Pawsey and Dr. R. N. Bracewell. (International Monographs on Radio.) Pp. x+361+23 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1955.) 55*s*. net.

THE invention of methods of producing and detecting electromagnetic waves of long wavelength which could signal information invisibly over long distances with no material medium was a remarkable outcome of the classical electrodynamics of the nineteenth century. Although radio has since then continued to attract the attention of physicists, especially for the knowledge it gives of the Earth's upper atmosphere and ionosphere, pure research interest in radio became dwarfed by comparison with that in atomic physics. Much effort, however, was devoted by radio physicists and engineers to the perfection of radio communication in its various forms, including the associated techniques of radar.

The astronomer has always held a unique place in science. In the interpretation of his observations he incorporates new aspects of fundamental scientific knowledge ranging from nuclear physics to cosmology. He observes phenomena in conditions impossible to attain in the laboratory. His inferences and speculations arouse widespread interest since they concern man's place in the universe. That radio should now be making a far-reaching contribution to astronomy is an unexpected development of recent years.

The explanation lies in the advance of radio technology as well as in astrophysical phenomena at radio wave-lengths. With radio receivers of special design the temperatures of objects can be measured by the radiation emitted to an accuracy of the order of one degree. Thus the temperature of the Moon can be measured by its radio emission. Radio can also measure the temperatures of ionized atmospheres such as the solar corona and interstellar ionized hydrogen in the vicinity of hot stars. In addition, there are solar and cosmic radio sources of amazingly high intensity, the interpretation of which is a challenge to the astronomer and physicist. Another discovery of great importance is the line emission at 1,420 Mc./s. (21 cm.) from neutral hydrogen, from which there is no visual emission. This spectral line enables not only the spatial distribution of hydrogen in the galaxy to be studied, but also the velocity by the Doppler displacement. A valuable aid in determining the structure of the galaxy is thus provided. Radar techniques have been extended to the study of reflexions from meteor trails and echoes from the Moon. In these various ways radio has become the new tool of astronomy and has the advantage of being able to 'see' through terrestrial clouds and interstellar dust.

Dr. J. L. Pawsey is the leader of an Australian research group, in the Commonwealth Scientific and Industrial Research Organization, which during the past ten years has played a leading part in the development of this new branch of astronomy. In their new book, Dr. Pawsey and Dr. R. N. Bracewell have written a valuable survey and guide to the fundamentals of the subject. It is an excellent introduction for physicists wishing to learn both the radio principles and the astronomical background. Equally, it explains the radio methods to the astronomer, and astronomy to the radio physicist or engineer.

It is plainly not easy to plan a book covering such a wide field. The authors have approached their task by describing radio techniques and propagation through an ionized gas; then follows a chapter on visual solar phenomena and solar physics. It is not until p. 144, with the chapter on solar radio waves, that the detailed account of the radio astronomical observations begins. An initial perusal of the chapters on solar and cosmic radio waves may be advisable in order to appreciate more thoroughly the significance of parts of the previous chapters.

The whole book is clearly written and well illustrated. The authors have endeavoured to be impartial in choosing material from the now vast number of papers on radio astronomy. It is, of course, natural that any author should be most advantageously placed in describing the work of his own laboratory. The rate of progress in radio astronomy is so great that a book on the subject can never be completely up to date when it is published. Although inevitably there are omissions of some recent findings, this book by Dr. Pawsey and Dr. Bracewell admirably covers the basic work and fundamentals.

J. S. Hey

The Boys' Country Book

Edited by John Moore. Pp. 352. (London: William Collins, Sons and Co., Ltd., 1955.) 15*s*. net.

Letters to a Young Naturalist

By Maxwell Knight. Pp. 192. (London: William Collins, Sons and Co., Ltd., 1955.) 10*s*. 6*d*. net.

THOSE who publish books for young people must find the task more difficult every day. First, because more books are being published than the reading public can buy. Secondly, because the books that are published are, on the whole, of good quality both in format and in content. It is not surprising, therefore, to find a well-known publishing company of children's books dipping into the past for ideas for new books which it hopes will be successful. The editor of the "Boys' Country Book" has turned to the "Boys' Own Book", published about 1860, and which contained much good advice about how to get the best out of riding, sailing, swimming, fishing, shooting and other activities beloved by boys; much country lore was intermingled with the advice. In his book John Moore has sought help from well-known writers like Spencer, Chapman, Jack Longland, Jacquetta Hawkes, Geoffrey Grigson, James Fisher, Eric Hosking and a score of others who write about country pursuits of diverse kinds. The majority have done their task well; a few have padded to fill out the pages and fortunately will be read and quickly forgotten by boys of good sense. Most of the book should arouse spontaneous interest with the majority of early teen-agers.

"Letters to a Young Naturalist" has been developed along the same lines as Gilbert White's "Natural History of Selborne". It may appeal more to young people than adults who, while recognizing the value of the natural lore it contains, would have preferred to have been spared some of the conversational exchanges between uncle, nephew and niece. Some children, too, might have preferred straightforward descriptions.

Careers for Graduates

A Handbook of Information. Edited for the University of London Appointments Board. Pp. vii+196. (London: The Athlone Press (University of London), 1955. Distributed by Constable and Co., Ltd.) 5*s*. net.

A VALUABLE service to graduates, headmasters and headmistresses, parents and scholars who hope to go to a university has been made available by the Appointments Board of the University of London. In 1924 the Board issued a handbook giving information about the avenues of employment open to graduates. This ran to three editions, the last being published so long ago as 1934. A fourth edition has now been prepared and is virtually a new book. So far as possible the employment of graduates and students in all faculties except theology has been considered, and the needs of both men and women have been taken into account.

The Handbook includes a select bibliography of current careers pamphlets, memoranda and books likely to be of interest to graduates, students and others; addresses likely to be required by those making inquiries and an index for convenience of reference. It is a model of succinct and lucid presentation, and should be a boon to many who have to choose careers for themselves; it will be even more useful to those who have to advise others about suitable means of training for careers. The weakness of the book is in its unconscious emphasis on 'professionalism'. It has long been known that Britain has not found enough enterprising young men to take the findings of scientific research and apply and develop them in industry. It is not enough to encourage graduates to seek careers in industry. They are most needed in production departments where qualities other than professional qualifications will be needed if they are to establish themselves and progress. It is difficult to see how, in a Handbook of this kind, the real challenge and opportunity which shop-floor industry presents could be presented. Perhaps that is a problem to which industry alone can find the answer.

T. H. Hawkins

The Numbers of Man and Animals

Edited by J. B. Cragg and N. W. Pirie. Pp. viii+152. (Edinburgh and London: Oliver and Boyd, Ltd., 1955. Published for The Institute of Biology.) 15*s*. net.

IN September 1954 the Institute of Biology arranged a symposium in order to bring together specialists in many different subjects connected with the numbers of men and animals. Their deliberations were recorded and have now been put together in book form. The central theme of the conference was that, while the growth of human populations is strongly influenced by social and cultural factors which are much less important in other species, *Homo sapiens* is still an animal and many aspects of his relationship with his environment, with other species, and with other members of his own species, are open to biological analysis. The analysis extends into most aspects of biology and sheds light not only on the reproductive habits of man but also on those of his domestic animals, parasites and pests. It became clear from the symposium that a great deal of money will have to be spent, and the number of people engaged on biological investigations increased, if essential information on population control or stabilization is to be obtained.

The book contains a record of all the papers presented by speakers as well as an idealized version of the discussion. It has been ably edited on behalf of the Institute of Biology, and the Institute has increased its prestige by arranging such a desirable and useful symposium.

A Manual of Paper Chromatography and Paper Electrophoresis

By Richard J. Block, Emmett L. Durrum and Gunter Zweig, with the co-operation of Raymond LeStrange, Winston H. Wingerd and Kathryn W. Weiss. Pp. viii+484. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1955.) 8 dollars.

THIS book is written in two sections: the first, by R. J. Block and G. Zweig, is on paper chromatography; and the second, by E. L. Durrum, is on paper electrophoresis. The first section is a revised version of the well-known monograph, by Block, LeStrange and Zweig, published in 1952, and maintains the high standard of that work. All practical aspects of paper chromatography are treated with remarkable thoroughness and presented clearly with many helpful recommendations. This section is a complete practical guide for all who employ paper chromatography.

There is ample justification for a monograph on paper electrophoresis, since it is now well established, but it is questionable whether the best course was to

have included it in one volume with another technique which occupies four-fifths of the space. Because of this restriction, the author has been unable to give the subject the thorough treatment that is such a notable feature of the first section. For example, little is mentioned about pathological sera, although the widest application of paper electrophoresis is in the clinical field, and, because of presentation, the beginner may have difficulty in finding guidance. However, Durrum has dealt adequately with the theoretical side and has been able, from his experience as a pioneer in this technique, to provide valuable information concerning many practical details. The whole volume is attractively produced and includes a very full bibliography. R. CONSDEN

The Archæology of Sussex

By E. Cecil Curwen. Second edition, revised. Pp. xx+330+32 plates. (London: Methuen and Co., Ltd., 1954.) 25*s*. net.

DR. E. CECIL CURWEN is a well-known prehistorian, and he therefore writes from first-hand knowledge. The second edition of his work on the archæology of Sussex has been entirely brought up to date and gives an excellent general picture of the remote past in that county. The book is not intended for the specialist, but rather for the instructed amateur interested in archæology who is studying the ancient story of one of the more interesting parts of Britain. Dr. Curwen first sets the stage and then proceeds to deal with Sussex during the Stone Ages, the Bronze and Iron Ages and the Roman period. All accounts of Saxon times in the county have been omitted.

The only criticism that can be made is of the deliberate omission of any kind of gazetteer of sites. Here I cannot agree with Dr. Curwen that such things are only useful to specialists. Anyone visiting the county and wishing to explore the countryside would have welcomed such a list of sites with their ages and references to any relevant literature concerning them. For the specialist, of course, such a gazetteer would have been invaluable. One rather fears that the publishers probably felt they could not face the extra expense involved. All the same, this second, revised edition is an excellent work and should be on the shelves of everyone interested in the remote past of that part of England. The illustrations are well chosen, both the line-blocks and the half-tones; and there are a welcome number of the latter. MILES BURKITT

Transistors

Theory and Applications. By Abraham Coblenz and Harry L. Owens. Pp. xv+313. (London: McGraw-Hill Publishing Company, Ltd., 1955.) 42*s*. 6*d*.

THREE years ago the authors gave lectures on the transistor at laboratories of the United States Signal Corps, shortly afterwards converting them into eleven articles for the journal *Electronics*, and now into a book. They have thereby attempted the formidable task of describing semiconductor physics, the metallurgy of germanium and silicon, techniques for manufacturing transistors and the equivalent circuits and applications of transistors, in language suited, as they say, to the practical technician.

The background physics given in early chapters is, however, disjointed and not always helpful or accurate. The uncertainty principle, for example, might well have been omitted. Davisson and Germer did not, in confirming de Broglie, pass electrons through a nickel slab to obtain clear, circular diffraction patterns on a photographic plate. Mobility, lifetime of minority carriers and the Hall effect are surprisingly left until much later in the book. The chapters describing the electronics, elementary circuits, small-signal applications and cascading of transistors—the centre third of the book—are, on the other hand, very satisfactory and should be of wide use. A chapter on large-signal applications is too confined to early work.

Manufacture is interestingly described, but diffusion is said to be the mechanism responsible for the *p-n* junction formed by that extensively used process of alloying indium to *n*-type germanium. The fact is that, during the furnace operation, the indium dissolves some germanium, much of which, contaminated with indium, is precipitated during cooling on to the undisturbed germanium, at first continuing the monocrystalline structure; diffusion is unimportant. Very little information is given on the design of transistors. The presentation maintains the high standards of the publishers. J. R. T.

An Introduction to the Theory of Numbers

By G. H. Hardy and E. M. Wright. Third edition. Pp. xvi+419. (Oxford: Clarendon Press; London: Oxford University Press, 1954.) 42*s*. net.

THIS text, widely recognized as probably the best general introduction to number theory, now appears in a third edition; G. H. Hardy died shortly after the publication of the second edition of 1945, and the revisions have been made by Prof. E. M. Wright, utilizing recent work. For example, the 1945 statement that there is no easy proof of the irrationality of π has been replaced by a concise and elegant proof due to Niven. But the major change is the insertion of an 'elementary' proof of the Prime Number Theorem, that the number of primes less than x is asymptotically equivalent to $x/(\log x)$. This proof, obtained by Selberg and Erdös and here given with improvements due to Wright, is by no means easy, but is technically elementary since it makes no use of complex function theory, and its discovery was the mathematical sensation of 1949.

Organic Syntheses

An Annual Publication of Satisfactory Methods for the Preparation of Organic Chemicals. Edited by William S. Johnson. Vol. 34, 1954. Pp. vi+121. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1954.) 28*s*. net.

AMONG the thirty-four preparative methods described in this volume are two for cycloheptanone, each starting from cyclohexanone: the first method, using nitromethane and Raney nickel, gives a yield of 40–42 per cent; the second, in which *p*-tolylsulphonylmethylnitrosamide is used as a source of diazomethane, gives 33–36 per cent. The great variety of organic compounds contained in this latest issue may be indicated by mentioning azelanitrile, cetylmalonic ester, dimethylfurazan, diphenylacetylene, hemimellitene, 3-methylthiophen, *o*-phthaldehyde and tetralin hydroperoxide. The editors invite chemists to submit accurate details for the preparation of other compounds which might find a place in future issues, either by reason of their general interest or because they illustrate useful synthetic methods.

JOHN READ

REVERSIBLE, HOST-INDUCED, CHANGES IN A STRAIN OF TOBACCO MOSAIC VIRUS

By F. C. BAWDEN, F.R.S.
Rothamsted Experimental Station, Harpenden, Hertfordshire

THE concept of variability is, perhaps, even less novel with tobacco mosaic virus, of which scores of strains have been reported, than with most pathogens, and describing yet another strain seems to need justifying. My justification is, not only that it changes more extensively than any strain previously described and that the large changes are reversible, but also that propagation in different host plants or environments so alters it that its properties depend less on those of the virus present in an inoculum than on the identity of the plants inoculated and the condition in which they grow.

Many of the reported strains were derived from Johnson's[1] tobacco virus 1, which is reasonably taken as the standard form of tobacco mosaic virus. These, like most others found infecting solanaceous plants, have very similar physico-chemical properties and are closely related serologically. Small antigenic differences have been detected between some, but most have been differentiated from the standard only because they cause a characteristic effect in some host plant.

A few strains differ from standard tobacco mosaic virus in many more characters than pathogenicity. Those most studied came from cucumber (*Cucumis sativus* L.)[2], plantain (*Plantago lanceolata* L.)[3] and tobacco (*Nicotiana tabacum* L.)[4]. Like the standard, they contain 6 per cent ribonucleic acid and occur in rigid rod-shaped particles of various lengths but uniform widths, 14·6 mμ for cucumber viruses 3 and 4 and 15·2 for the others[5]. They are precipitated by antiserum prepared against the standard tobacco mosaic virus, but the serological relationship is remote and most of the antigens contained by each one are specific to it[2]. They contain different quantities of some amino-acids, and a given amino-acid may occur in one but not in another[6]. They have different isoelectric points, electrophoretic mobilities and sensitivities to inactivation by ultra-violet radiation[4].

Some of these diverse types have been observed over years and in a range of plants without losing their distinctive properties. Like the standard tobacco mosaic virus, they give rise to variants with different pathogenicities, but otherwise they stay constant. It has been reasonable to assume that, if all have derived from a common ancestor, their current states were reached as the result of many small changes accumulated while they evolved separately, perhaps in different plant species, over a very long time. This may be true, but the behaviour of the virus I have been using shows that a protracted period of evolution is not always necessary to change a strain from one resembling the standard form into one with many distinctive properties.

This virus was discovered causing a mosaic disease of cowpea (*Vigna sinensis* Endl.) in Nigeria[7] and provided the first record of a strain of tobacco mosaic virus that infects leguminous plants systemically, although many cause necrotic local lesions in some varieties of French bean (*Phaseolus vulgaris* L.). When White Burley tobacco seedlings in a glasshouse are inoculated with the virus from cowpea, after first producing necrotic local lesions, they become systemically infected and show symptoms very like ordinary tobacco mosaic. The virus in the systemically infected leaves is closely related serologically to the standard tobacco mosaic virus and resembles it in all properties for which I have tested. The only way in which the two are distinguished readily is by inoculation to some leguminous plants, of which I have mostly used the Prince variety of French bean, when the cowpea virus produces a severe systemic disease and the other has no effect. Varieties of French bean, such as Pinto, which give necrotic local lesions with the standard strain, also give only local lesions with the cowpea virus from tobacco.

The virus obtained from diseased Prince beans is only remotely related serologically either to tobacco mosaic virus or to the cowpea virus obtained from mottled tobacco leaves. Specific precipitates are obtained only when the heterologous antiserum is used much more concentrated than is needed to precipitate its homologous antigen, and the cowpea virus from tobacco probably has fewer than 10 per cent of its antigens in common with the virus from beans. The cowpea virus obtained from the two hosts also has different electrophoretic mobilities, $-4{\cdot}7 \times 10^{-5}$ from bean and $-9{\cdot}4 \times 10^{-5}$ cm.^{2}/sec./volt from tobacco; the virus obtained from bean is also inactivated with much less exposure to ultra-violet radiation. I have not studied their amino-acid compositions, but, by analogy with other strains that have been examined, it can be assumed the two will differ considerably.

Pinto beans inoculated from infected Prince bean show no local lesions, but develop a systemic disease like that in Prince. Tobacco seedlings inoculated from systemically infected Pinto beans give local lesions and a systemic mosaic, but virus from the mottled tobacco leaves produces only necrotic local lesions when returned to Pinto.

Except for the few that affect cucumber, all strains of tobacco mosaic virus produce necrotic local lesions in *Nicotiana glutinosa* L. when growing at usual glasshouse temperatures. The size and character of these lesions vary a little with the age of the plants, and some strains produce rather larger and better defined lesions than others[3]. Cowpea virus obtained from mottled tobacco leaves produces lesions like those produced by standard tobacco mosaic virus; at 20° C. they become visible in 40–48 hr., and they reach a diameter of 3–4 mm. and are clearly defined with a pale centre surrounded by a broad ring of black necrotic cells. The cowpea virus obtained from bean produces lesions that differ more from the standard type than do those produced by any other strain of tobacco mosaic virus I have studied; the lesions are not visible until four days, few reach a diameter of 1 mm. and many are wholly white, though some have incomplete rings of black. The

differences are ample to identify small amounts of the tobacco form of the virus in the presence of much more of the bean form, and the production of the tobacco form in plants inoculated with sap from beans can be readily detected by inoculations to *N. glutinosa*.

When tobacco leaves are inoculated, washed thoroughly, and samples taken at intervals to be macerated and inoculated to *N. glutinosa*, the course of virus multiplication can be followed. With sap from tobacco as the inoculum, less virus is recovered 24 hr. after inoculation than an hour afterwards, but newly produced virus is usually detectable 48 hr. afterwards, and at 72 hr. this has already much increased and it continues to do so rapidly. With sap from bean as the inoculum, less virus is usually recoverable 48 hr. after inoculation than an hour afterwards; lesions begin to form after about 72 hr., and newly produced virus then becomes detectable. This is the bean form, for it produces only small, slowly developing lesions in *N. glutinosa*. It does not occur much more abundantly in later extracts, but at five days extracts from some plants start to produce large, quickly developing lesions, and from then on the amount of such virus in successive extracts increases rapidly with time. The plants of which the inoculated leaves give extracts that contain the tobacco form of the virus are those that later show systemic symptoms. This almost always happens in young seedlings, but becomes less common as the age of plants increases and is rare in those with leaves longer than 15 cm. Young tomato (*Lycopersicon esculentum* Mill.) and *Datura tatula* L. plants are also more likely than old ones to yield the tobacco form of the virus when inoculated from infected beans. Plants that are not members of the Solanaceae can also produce a changed form of the virus. Both forms multiply locally in leaves of sugar beet (*Beta vulgaris* L.), inoculum from beans producing lesions and from tobacco not; leaves inoculated from beans first yield only the bean form, but after a week yield both.

The tobacco form seems not to be produced in *N. glutinosa* inoculated from beans, and when transferred from one *N. glutinosa* to another the virus has continued to produce only small, slowly developing lesions. From inoculated plants kept in usual glasshouse conditions with a mean temperature of 20° C., very little virus is recovered. *N. glutinosa* inoculated from beans and kept at 37° C. produce much more virus although their leaves show no lesions, but again it all seems to be of the bean form. The loss of pathogenicity towards *N. glutinosa* at 37° C. provides another contrast with the behaviour of the cowpea virus obtained from tobacco, for this, like standard tobacco mosaic virus, produces large chlorotic lesions.

The cowpea virus from beans also behaves differently in tobacco plants kept at the two temperatures. Inoculated leaves of plants kept at 37° C. show no lesions even after many days, although they then contain much more virus than do leaves at 20° C. when lesions develop. All the virus produced at 37° C. seems to be of the bean type and no large lesions are produced by inoculations to *N. glutinosa*. After a week at 37° C., plants moved to usual glasshouse conditions soon show large necrotic rings. Many show only this symptom, and from these the bean form only of the virus has been obtained; but the young leaves of some later become mottled and they then contain the tobacco form.

I have done little to study the course of infection when bean leaves are inoculated from infected tobacco plants, for the work is complicated by the combination of a small virus content in such inoculated leaves with substances that inhibit infection in *N. glutinosa*. However, it has been possible to show that inoculated bean leaves at first yield only virus that produces large lesions in *N. glutinosa*, but that, after six to eight days, they also yield virus that produces the small, slowly developing lesions.

Changes in the properties of a virus culture when passed through different hosts could be explained simply by postulating that the culture contains two different strains that multiply differentially in the different hosts. My many attempts to gain evidence of such a mixture failed, and several facts conflict with this simple explanation. For example, inoculum from Prince beans, which will produce the tobacco form of the virus when inoculated to many species, produces no large lesions in *N. glutinosa*, and this inoculum can fail to produce the tobacco form when inoculated to tobacco plants in a physiological state that permits this form to infect and multiply when it is added to the inoculum. Also, if two strains are concerned, they must always go together through single local lesions in *N. glutinosa*. I have used extracts from single lesions, produced with diluted inocula, to infect other *N. glutinosa*, and then repeated the process serially. Ten cultures established in this way by four transfers through local lesions, six originally produced by virus from tobacco and four from bean, all resembled the bulk inoculum in their ability to infect both bean and tobacco plants and to show the characteristically different properties when propagated in the two species.

The failure of Pinto beans to become systemically infected when inoculated with extracts from mottled tobacco leaves also tells against the idea that the extracts contain the bean form of the virus. Further, Prince beans inoculated from tobacco take several days longer to show systemic symptoms than do similar plants inoculated from other beans. Similarly, tobacco seedlings show systemic symptoms sooner when inoculated with tobacco sap diluted almost to the infection end-point than when they are inoculated with undiluted sap from infected Prince beans. It seems, then, that inocula from mottled bean or tobacco leaves contain only one form of infective virus, and that the second form occurs only after the first has infected and multiplied in inoculated leaves of the alternative host.

After a prolonged period in either bean or tobacco, during which it has passed through many plants, the virus will still return to the other host, with its behaviour there apparently unchanged. Thus there seems to be a continuity of inherited characters, suggesting a genetic framework that remains stable through considerable changes in the gross properties of the whole virus particles. This could be conferred by the genetic determinants combining in new ways when new particles are synthesized; or the continuity may be only apparent, simulating stability by precisely reversible mutations. Before the second form occurs, some millions of particles are synthesized in inoculated leaves of the alternative host, so opportunity for such rearrangements or changes exists. Equally, though, the genetic material may remain unaltered, and the different forms the virus adopts in different hosts may be equivalents of phenotypic variations, perhaps providing extreme examples of

the wide range of different proteins that can combine with the same nucleic acid.

There is much evidence that the multiplication of the standard tobacco mosaic virus is not the precise replication of the infecting particle to give a uniform end-product. In addition to infective variants, distinguishable by their distinctive pathogenicities and usually, though with little justification, called mutations, extracts from infected plants contain a range of specific proteins that resemble the virus in some respects but are not infective[8-10]. Plants systemically infected with the cowpea virus also yield more than one product, and beans appear to contain an unusually large proportion of non-infective protein. Whereas sap from infected beans contains about a tenth of the total specific protein in sap from tobacco, the tobacco sap is more than a hundred times as infective when tested on *N. glutinosa*.

Electrophoretic tests on purified preparations of the bean form, at 2 mgm./ml., show two components, a major one with a mobility of $-4{\cdot}7 \times 10^{-5}$ and a minor one with a mobility of $-9{\cdot}4 \times 10^{-5}$ cm.^{2}/sec./volt, the same as that for the single component detectable in preparations of the tobacco form at 2 mgm./ml. The minor component is about 10 per cent of the total protein; if it were the tobacco form of the virus, it should be detected by inoculation to *N. glutinosa*, for artificial mixtures containing 99 per cent of virus from bean and 1 per cent from tobacco produce the characteristic, large, rapidly developing lesions; but the preparations give only the small, slowly developing lesions. When examined at 20 mgm./ml., purified preparations of the cowpea virus from tobacco also show a small peak, which moves with the same speed as the main peak in preparations of the bean form. No such component has been noted in purified preparations of the standard tobacco mosaic virus, but non-infective proteins with this mobility have been obtained from sap after the infective protein was removed by high-speed centrifugation[10]. As components with the same mobility accompany two strains, only one of which infects beans, there is no need to regard that from tobacco plants infected with the cowpea virus as the bean form of this virus. Rather it is evidence that infection with different strains can lead to the synthesis of materials with common properties. There are other minor components, both in extracts from plants infected with the standard tobacco mosaic or the cowpea virus, with different mobilities, and these provide still further evidence of the range of anomalous proteins that occurs in cells when their metabolism is deranged by infection. It seems that, of the proteins that are synthesized, some may be able to combine with nucleic acid to give stable particles that are also infective, and others not. In the diverse metabolisms of such plants as bean and tobacco, or in tobacco at 20° and 37° C., the nucleic acid will be given opportunities to combine with different proteins. In an environment where the initial infecting particles are of a type that is as stable and as infective as any other that is synthesized, reasonable continuity of properties can be expected; but where they are not, they will soon be superseded by any more stable form that is also better fitted to spread from one cell to another.

The cowpea virus is not unique in its ability to adopt very different guises when multiplying in various kinds of hosts. Suspecting that some other of the reported diseases of leguminous plants might also be caused by strains of tobacco mosaic virus, I tested southern sann-hemp mosaic virus[11] from India. It is not identical with the cowpea virus from Nigeria, but the two behave similarly. The sann-hemp virus can be transferred between Prince bean and tobacco plants, and when derived from tobacco it closely resembles the standard tobacco mosaic virus, whereas when derived from beans it has properties very like those of the cowpea virus from bean.

I thank Mr. R. M. Lister and Dr. S. P. Capoor for sending me the cowpea and sann-hemp viruses, and Dr. A. Kleczkowski for making the electrophoretic measurements.

[1] Johnson, J., *Wis. Agric. Exp. Stat. Res. Bull.*, 87 (1927).
[2] Bawden, F. C., and Pirie, N. W., *Brit. J. Exp. Path.*, **18**, 275 (1937).
[3] Holmes, F. O., *Phytopath.*, **31**, 1089 (1941).
[4] Siegel, A., and Wildman, S. G., *Phytopath.*, **44**, 277 (1954).
[5] Bernal, J. D., and Fankuchen, I., *Nature*, **139**, 923 (1937).
[6] Knight, C. A., "Advances in Virus Research", **2**, 153 (1954).
[7] Lister, R. M., and Thresh, J. M., *Nature*, **175**, 1047 (1955).
[8] Bawden, F. C., and Pirie, N. W., *Brit. J. Exp. Path.*, **26**, 294 (1945).
[9] Takahashi, W. N., and Ishii, M., *Nature*, **169**, 419 (1952).
[10] Commoner, B., Yamada, M., Rodenberg, S. D., Wang, T. Y., and Basler, E., *Science*, **118**, 529 (1953).
[11] Capoor, S. P., *Current Science*, **19**, 22 (1950).

MODELS FOR METALLO-ENZYMES*

By Dr. R. J. P. WILLIAMS

Wadham College and the Inorganic Chemistry Laboratory, University of Oxford

THE importance of metal ions in biological systems has become more clearly recognized in recent years. Tentative explanations have been put forward of the role of the cations in the reactions of enzymes; but many of these explanations lack a reasonable basis when they are compared with the known interactions of cations with simpler organic molecules[1]. The purpose of the present article is to direct attention to such shortcomings and to consider different possible functions which cations could assume in biological systems. To this end the article consists of a critical survey of the properties of complex ions in solution, with special reference to their absorption spectra and stability, followed by a brief discussion of some properties of metallo-enzymes.

* Substance of four public lectures on "Metal Complexes as Models for Metallo-enzymes" given at University College, London, on November 17, 24, December 1 and 8. The lectures will be published by the Athlone Press, University of London, in due course.

Stability of Complex Ions

Sufficient data have been obtained in the study of complex ions in aqueous solution to warrant the general conclusion that no one parameter, such as the electronegativity of the cations, can be dominant in the formation of all the complexes of any one ligand. Even the correlation between a 'corrected' electronegativity and the stability of a wide variety of cations with one ligand should be suspected as

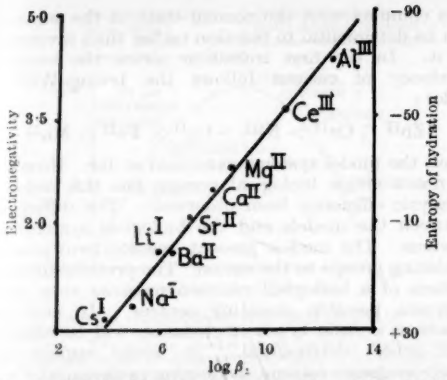


Fig. 1. Relationship between the logarithm of the stability constant for a number of complexes of dibenzoyl-methane with A-subgroup cations and either the electronegativity of the cation or its entropy of hydration

arising rather from the nature of the corrections than from any fundamental importance of the correlation[2]. For example, if the IA, IIA and IIIA subgroup cations of the periodic table are compared in their ability to form complexes with an anion such as dibenzoyl-methane, then the stability of the complexes is as good a function of the entropy of hydration of the cations as of their electronegativity (Fig. 1). The entropy-change of the reaction, a charge neutralization,

$$M^+ + L^- \rightleftharpoons ML$$

is very probably the main 'driving force' in the formation of these A-subgroup cation complexes and is derived from the loss of hydration[2]. The data available at present suggest that reactions of these cations, involving neutralization of charge, are often endothermic[3]. With these same cations the parallel between electronegativity and stability of complexes arises coincidentally from the rough relationship between electronegativity and entropy of hydration. Reasons for this correlation are not difficult to find, for among A-subgroup cations electronegativity $\propto$ ionization potential $\propto$ ionic potential $(z/r) \propto$ entropy of hydration.

On the other hand, the dependence of stability upon the 'electronegativity' of the ground state of the cation in the series

$$Zn^{II} < Cu^{II} > Ni^{II} > Co^{II} > Fe^{II} > Mn^{II}$$

is well established, although the relationship mainly applies to the four-coordinated complexes[2]. There are several exceptional complexes which do not conform to the general pattern, but the exceptions only appear upon six-coordination. Notable among exceptional ligands is orthophenanthroline, which forms a particularly stable ferrous complex. The ferrous ion does not have the ground-state electronegativity in this complex. Now although on an absolute basis the ferrous ion does not form a more stable complex with phenanthroline than does the cupric ion, the relative differences in stability in the presence of a second ligand, for example, glycine, are such that ferrous can appear as a phenanthroline complex while cupric appears as a glycine complex in a mixed solution of both ligands. Analysts frequently employ a combination of two such reagents. They refer to the second one as a masking reagent. Such masking reactions are particularly important in biochemistry, for they lead to a selective combination of cations and ligands, not on an absolute basis of stability, but on the relative basis of competition of excess ligands for all kinds of cations. Inspected in this way, it seems at least probable that in a biological system at *p*H 7·2, zinc should be found held in complexes with sulphide, iron in complexes with imines, and magnesium found mostly with oxyanions[1].

Bonding in Transition Metal Complexes

The bonding in complexes of transition-metal cations is now known to be more complicated than was at first thought[4]. The general suggestion that π-bonds as well as σ-bonds control stability has been increasingly supported since it was first introduced by Pauling[4,6–8]. The relevant molecular orbitals for both types of bond can now be given, and it can be shown theoretically and experimentally that there is need to include two sets of such interactions: first, those described by Pauling, in which an empty orbital of either the ligand or the cation acted as an acceptor of electrons from its coordination partner; and second, the further bonds between half-filled *d* orbitals of the cation and the full levels of the ligand necessitating the partial use of anti-bonding states (Fig. 2). The total stability will be a function of the proper mixture of the two interactions. A change of emphasis is now required when relating the stability of a complex with ionization potentials or electronegativities, for the latter do not truly reflect the energy-levels of a cation in the field of a ligand, that is, the electronegativity is a function of the bonding. In particular, the original discussion given by Irving and Williams of their stability series is seen to be incorrect, in that it ascribed all bonding differences to acceptor characteristics of the cations, without the essential consideration of the ways in which both acceptor and donor properties of cations were influenced by the ligand. Discussions by Fernelius and his co-authors[2] are similarly in error. A proper consideration of the effect of the ligand-field[5] explains why the six-coordinate complexes of nickel are equally stable with the cupric complexes, an observation not in accord with the earlier theories. The Irving–Williams series is an empirical order applicable to complexes in which replacement of water takes place in four or fewer positions in the coordination sphere of the cation[3].

Absorption Spectra of Complex Ions

The absorption bands of chelating ligands such as 8-hydroxy quinoline are affected by cations to but a

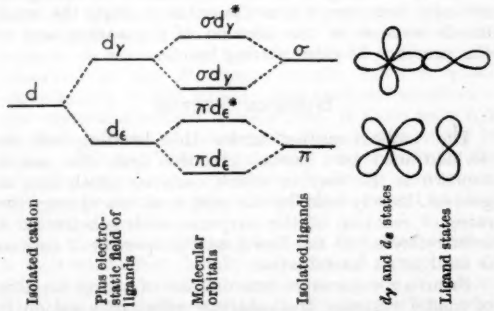


Fig. 2. Stark splitting of *d*-states together with the formation of bonding and anti-bonding orbitals between the split *d*-states and states of the ligand. The diagram also illustrates the way in which the orbitals overlap

slight extent. The shifts appear to be in the order $Zn^{II} < Cu^{II} > Ni^{II} > Co^{II} > Fe^{II} > Mn^{II}$ and $Zn^{II} > Mg^{II} > Ca^{II} > Ba^{II}$. These orders clearly reflect the 'electro-negativity' of the cations[9]. In their complexes with ligands such as porphyrin and phthalocyanine, however, the 'electronegativity' of all the cations is not that of their ground states, for several of them are in states of lower spin-multiplicity; for example, in nickelous porphyrin and cobaltous phthalocyanine. These and other cations such as palladous have an enhanced electronegativity in porphyrin and similar complexes, and the order of the shifts of the ligand absorption bands becomes[9]:

$$(Fe^{II}) > Ni^{II} > Co^{II} > Cu^{II} > Zn^{II} > (Fe^{II}) > Mn^{II}$$

The ferrous complex has different properties depending upon the solvent in which the complex is dissolved. In dioxan the absorption band is at a wave-length and of an intensity similar to that of the zinc complex; but in pyridine the absorption spectrum closely resembles that of a nickel complex. It can be said that the electronegativity of the ferrous ion is a function of its coordination—in pyridine the ferrous complex is diamagnetic, but it is paramagnetic in dioxan.

Not all the absorption bands of complex ions are to be described as modified ligand bands. In the ferrous, cuprous and cobaltous complexes of diimines, for example, terpyridyl, there are absorption bands which can only be attributed to transitions of the cation electrons bound in molecular orbitals which include the ligands. The influence of substituents in the ligand upon the position of the absorption bands in these complexes further suggests that the excitations involved are partial electron transfers to the ligand[9]. Now while there are many examples of partial charge-transfer bands in which charge is increased on the ligand, there are many bands in the absorption spectra of the complexes of oxidizing cations which can be confidently attributed to partial transfer of electrons to the cation. Of particular interest are the bands in ferric complexes generally, and in particular with phenanthroline and porphyrins[9].

All the absorption bands discussed so far are intense. Certain bands of transition metals, $d - d$ spectroscopic transitions, are usually weak. It is now thought that these d states can become mixed with energy states of the ligand, forming the molecular orbitals referred to in the above discussion of stability, both through π- and σ-bonding (Fig. 2). The formation of such molecular orbitals can be used to account for features of the band position and band intensity in the spectra of complexes[7,8]. In biological systems, however, it is not possible to study the weak bands because of the dilution of the cation and of the presence of other strong bands.

Biological Systems

The subject-matter under this heading will be divided into two parts. In the first, the major concern is the way in which cations, which are, in general, loosely held by the enzymes, can change the rates of reaction of the enzymes with substrates. A brief reference to the Lewis acid properties of cations is used as an introduction.

From a comparative examination of a large number of model systems, the catalytic effect of a cation in acid-base reactions has been shown to parallel the stability of the complexes of the cations with the activated state of the substrate[10,11]. The formation of a complex with the normal state of the substrate can be detrimental to reaction rather than favourable to it. In the first transition series, the catalytic efficiency of cations follows the Irving–Williams order:

$$Zn^{II} < Cu^{II} > Ni^{II} > Co^{II} > Fe^{II} > Mn^{II}$$

in all the model systems examined so far. However, in not a single biological system has this order of catalytic efficiency been observed[1]. The differences between the models and the biological systems are obvious. The models present one (or two) possible chelating groups to the cation. The protein/substrate system of a biological reaction presents very many different possible chelating centres. In acid-base reactions certain types of chelation will be effective and others detrimental. It would appear that electronegative cations, combining preferentially with sulphydryl groups, generally form chelates detrimental to acid-base reactions, and that therefore such cations as lead, mercury, copper and nickel are often enzyme poisons. The best cations for the catalysis of acid-base reactions, which involve substrates which can coordinate through oxygen only, are magnesium and manganese. If the substrate contains nitrogen-coordinating groups, on the other hand, then zinc, cobaltous and ferrous are often equally effective. If the cation function is not to bind the substrate but is merely to provide a method of bringing a coenzyme and a protein together in a correct stereochemical alignment, then the competition that must be considered is that between the chelating centres of the coenzymes, of the various sites of the protein, and of the substrates. Consideration of these possibilities reveals the ways in which one cation acts as an inhibitor, another as a catalyst[1], or even the way in which a cation can be an activator of an enzyme at low concentration and an inhibitor at high concentration[12].

The second major influence of cations in biological systems is upon oxidation-reduction reactions. For example, the reactions of iron porphyrin proteins are of the utmost importance in biological systems. They carry oxygen and transport electrons. However, there is a complete parallel group of copper enzymes which perform similar functions, but these proteins contain no porphyrin. Again, there is a group of cobalt complexes, not found in biological systems as yet (apart from vitamin B_{12}), which can show certain of the reactions of the biologically important copper and iron compounds. From this evidence I tentatively conclude[13] that the function of the ligand in all these complexes is to induce similar properties in three dissimilar cations. The absorption spectra of the complexes of these cations reveal that the property induced is the willingness of the reduced states of the cations, cobaltous, ferrous or cuprous, to donate d_ϵ electrons into π-orbitals of their ligands[9]. This donation of d_ϵ electrons accounts for the double bonding in oxygen, carbon monoxide, nitric oxide and cyanide complexes. The d-electrons are also donated to any other unsaturated ligand to which the cations are bound, for example, to porphyrin in a ferrous porphyrin complex. When ferrous is bound to both porphyrin and carbon monoxide, there is a competition between the two ligands for the d-electrons. Now the absorption of light by the ferrous porphyrin results in enhanced donation of electrons to this ligand, as in the models (see above), that is, the removal of d-electrons from the cation. The removal of d-electrons must weaken bonding to

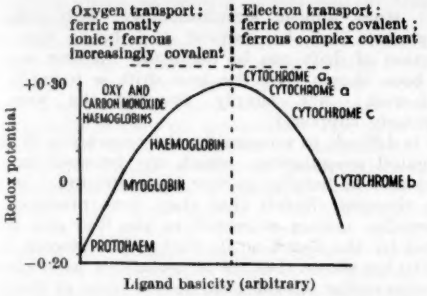


Fig. 3. Proposed relationship between ligand basicity (or electronegativity) and the oxidation-reduction potentials of their iron complexes. The basicity, plotted on an arbitrary scale, is used in preference to the electronegativity because of the difficulty of assessing the electronegativity of the ligand

carbon monoxide. The sensitivity of carbonyl ferrous porphyrin complexes to light absorption can now be understood. Many other features of the absorption spectra and properties of the ferrous porphyrin proteins can be explained in terms of the spread of the *d*-electrons over the porphyrins[13].

The iron and copper proteins also have in common oxidase properties. Small differences in coordination bring about the large differences in reactivity between the oxidases and the oxygen-carrying proteins. For example, cytochrome *b* is not a very different protein from hæmoglobin—they contain the same ferrous porphyrin. There is, however, the major difference that the ferrous ion is only diamagnetic in hæmoglobin when combined with oxygen, while the ferrous ion in cytochrome *b* is always diamagnetic. Only when the ferrous ion is diamagnetic is it a good electron donor. In the cytochrome, then, ferrous donates electrons to the porphyrin (the only ligand which is a good acceptor) and is readily oxidized. In oxyhæmoglobin, on the other hand, the major electron acceptor is oxygen (oxygen restricts electron donation to the porphyrin) and therefore prevents the hæmoglobin entering oxidative reactions. A detailed study of the absorption spectra and paramagnetism of these and other iron complexes[12] as compared with the model systems gives very strong support for these views. In fact, a study of the absorption spectra and the oxidation-reduction potentials of the whole series of hæm-proteins known in biological systems reveals steady gradations in properties which can be correlated with the change in the function of the proteins. Some of the properties are referred to in Fig. 3. Other series of ferrous complexes show similar changes in the same properties (for example, the phenanthrolines and the simple porphyrins), but in these cases the series obtained are the same as those formed by gradations of basicity (or electronegativity) among the ligands of the complexes. It seems likely that the hæm-proteins are also arranged in a series of changing ligand basicity (or electronegativity) as in Fig. 3.

[1] Williams, R. J. P., *Biol. Rev.*, **28**, 381 (1953).
[2] Van Uitert, L. G., Fernelius, W. C., and Douglas, B. E., *J. Amer. Chem. Soc.*, **75**, 2736 (1953).
[3] Williams, R. J. P., *J. Phys. Chem.*, **58**, 121 (1954). Martell, A. E., "Ann. Rep. Phys. Chem.", **6**, 273 (Annual Reviews, Inc., Stanford, 1955).
[4] Orgel, L. E., *J. Chem. Soc.*, 4756 (1952); *J. Chem. Phys.*, **23**, 1004 (1955).
[5] Owen, W., *Proc. Roy. Soc.*, A, **227**, 183 (1955).
[6] Pauling, L., "Nature of the Chemical Bond", 250 (Cornell University Press, N.Y.).
[7] Orgel, L. E., *J. Chem. Phys.* (in the press).
[8] Williams, R. J. P., *J. Chem. Soc.* (in the press).
[9] Williams, R. J. P., *J. Chem. Soc.*, 137 (1955). Orgel, L. E., *Quart. Rev. Chem. Soc.*, **8**, 423 (1954).
[10] Prue, J., *J. Chem. Soc.*, 2331 (1952).
[11] Pedersen, K. J., *Acta Chem. Scand.*, **3**, 676 (1949); **6**, 285 (1952).
[12] Vallee, B. L., "Advances in Protein Chemistry" (in the press).
[13] Williams, R. J. P., *Chem. Rev.* (in the press).

MOVEMENTS IN THE IONOSPHERE

THE Royal Astronomical Society held a Geophysical Discussion on November 25 on the subject of irregularities in the ionosphere and their horizontal movements. Most of the British workers on the subject were present, and the meeting took the form of a free discussion on a series of points introduced by the chairman. Those taking part were J. A. Ratcliffe (in the chair), W. J. G. Beynon, E. N. Bramley, B. H. Briggs, P. C. Clemmow, M. Dagg, J. W. Dungey, E. T. Eady, J. S. Greenhow, A. Hewish, I. L. Jones, M. Ryle, R. S. Scorer, K. Weekes and M. V. Wilkes. The main points in the discussion are summarized below, and the initials in brackets refer to the speakers.

Horizontal drifts of irregularities of electron density in the ionosphere are detected at different heights by radio methods as follows: between about 80 and 100 km. by the drift of meteor trails; between about 90 and 130 km. (*E* region) by observation of the fading on close-spaced receivers; between about 200 and 300 km. by similar fading observations, and also by the observation of large-scale travelling 'ripples' which show as 'kinks' on $P'(f)$ or $P'(t)$ ionospheric records; and above 400 km. by the fading, or scintillation, of the radio waves received from radio stars.

Briggs and Spencer have given a summary of the knowledge obtained by these methods[1]. In the *D* and *E* regions there is a mean drift, with a velocity of about 50 m. sec.$^{-1}$, which changes with the seasons and on which is superimposed a drift with a velocity of about 30 m. sec.$^{-1}$ that rotates twice in 24 hours. In the lower *F* region the east–west component of the velocity is towards the east by day and towards the west by night. The north–south component by day is towards the pole in summer and towards the equator in winter; by night it is small. The ripples observed in the *F* region usually have a quasi-wave-length of 100–200 km. and their deformation in the vertical direction is such that, if there were real concave mirrors of this extent, their depth would be 5 km. or less. The irregularities responsible for the scintillation of radio stars are markedly anisotropic, and are probably a few kilometres in extent in their smallest dimension.

The discussion brought out the fact that there is a well-established height-variation of the phase of the 12-hourly rotating component in the *E* region. This has been observed (J. S. G.) by working with meteors, the height of which can be measured, and by observing (I. L. J.) the fading of waves on two neighbouring frequencies, which are reflected from some-

what different heights. The results of the two sets of observations agree, and indicate that the phase advances by about 5° km.$^{-1}$ for heights between about 85 and 130 km. The meteor observations (J. S. G.) also indicate that the phase alters with seasons, and both sets of observations show that the magnitude of the rotating velocity-component increases with height. Although at greater heights movements of irregularities in the electron density will not necessarily follow the movements of the air (P. C. C.), or of the surrounding electrons, there is every reason to suppose that meteor trails, at levels near 90 km., indicate the movements of the air itself. Since the deductions made from observations of meteor trails are consistent with those made on the fading of reflected waves, it is reasonable to suppose that the latter, also, indicate air movements. It is then interesting to inquire what sort of movement might be expected from theoretical considerations.

The theory of semi-diurnal tides in the atmosphere (K. W., M. V. W.) leads us to expect a rotating component of the drift velocity of the order of the observed one in magnitude, but until now the phase has not been as expected. The new observations that the phase varies with height could be explained in terms of a temperature gradient, but it is difficult to explain why the phase changes with the seasons.

Since in the *E* region the electron movements seem to be determined by the air movements, it is interesting to consider what air movements might be produced by other than 'tidal' forces. It was pointed out (E. T. E., R. S. S.) that horizontal temperature gradients might be great enough to produce eddies, and that waves produced by the flow of air over obstacles near the ground could probably extend upwards into the *E* region. It was also pointed out (R. S. S.) that the technique of observing noctilucent clouds has been improved recently and that observations on a larger scale can be expected in the next few years.

The most interesting piece of new information (B. H. B.) about the lower *F* region was that simultaneous measurements made on large-scale ripples, and on the small-scale irregularities which produce fading, show that both these irregularities travel with the same speed. If this observation is correct, it has important implications for the theory, since the present tendency is to suppose that the 'ripples' represent the travel of a distortional wave-motion through the electrons, and that the movements of the small-scale irregularities are produced by the joint effect of electric and magnetic fields.

Spencer[2] has shown that the scintillations of radio stars are produced by irregularities of electron density, at heights above 400 km., which are elongated and are oriented along the direction of the Earth's magnetic field. These irregularities produce an anisotropic diffraction pattern at the ground, of which the direction of elongation changes through the day and through the year as the position of the star changes. The observations have now been continued (I. L. J.) for a complete year, and the expected results have been obtained. A more detailed analysis of the results has shown that the length of the irregularities is about three or four times their breadth, and not about ten or twenty times as was originally supposed. Because the irregularities are elongated, any measured drift velocity is biased towards a direction perpendicular to the long axis. In practice, only the component of the true drift in this direction can be observed. By making observations (M. D.) on two radio stars almost simultaneously, two velocity components can be derived and hence the true direction of drift can be deduced. In this way, it has been shown that the true drift is towards the south-west; not simply towards the west as previously supposed.

It is difficult to account for the occurrence of these elongated irregularities, which are detected only at night and at heights greater than 400 km. It was once thought (Ryle[3]) that they were produced by interstellar matter attracted to the Sun and intercepted by the Earth on its dark side. Recent work (A. H.) has shown that the irregularities, as evidenced by radio stellar scintillation, do not occur at the same time at Washington, D.C., Cambridge and in the Gold Coast. Scintillations are twice as common at sunspot minimum as at sunspot maximum. Theory suggests that, at these heights, movements of electrons would not follow movements of the air, so that simple turbulence is not a likely cause for the irregularities. If, however, there was turbulence in the *E* layer for any reason, it was suggested (M. D.) that the resulting irregular electrostatic field might be transferred, along the magnetic lines of force, to the *F* region in such a way as to produce irregularities of electron density there. In support of this idea it was stated that increased scintillations are sometimes accompanied by a magnetic disturbance, but there is no one-to-one correlation. It was also suggested (J. W. D.) that a type of electromagnetic disturbance could perhaps travel from the *E* to the *F* region along a line of magnetic force, in such a way as to produce irregular variations in the *F* layer.

Attention was also directed (M. R.) to recent studies on the counterglow by workers in the U.S.S.R. They have interpreted this as a result of streaming of the upper atmosphere away from the Earth on the night side. This atmosphere is supposed to be repelled by the Sun, much as a comet's tail is repelled. It would tend to stream along the magnetic lines of force, and possibly with an irregular density, and might be responsible for the scintillations.

J. A. Ratcliffe

[1] Briggs, B. H., and Spencer, M., "Rep. Prog. Phys.", **17**, 245 (1954).
[2] Spencer, M., *Proc. Phys. Soc.*, **68**, 493 (1955).
[3] Ryle, M., and Hewish, A., *Mon. Not. Roy. Astro. Soc.*, **110**, 4, 381 (1950).

OBITUARIES

Sir Arthur Trueman, K.B.E., F.R.S.

When Sir Arthur Trueman died on January 5 at the early age of sixty-one, in his house in London, his passing left a gap in many circles created by his wide intellectual interests and attainments. By profession he was a geologist, and few have attained greater eminence or contributed more to the science by research, by teaching, or thorough administration. His early training at the High Pavement School and later at University College, Nottingham, laid the foundations for his subsequent eminence as a palæontologist concerned with various aspects of the faunas and of the stratigraphy of Carboniferous and Jurassic rocks. These researches were carried out during an unusually full and rich academic career, which commenced with his appointment as lecturer at University College, Cardiff, in 1917, where he came under the influence of Franklin Sibly. This was followed by appointment to the chair of geology and geography at Swansea (1921), and the subsequent

tenure of chairs at Bristol (1933) and at Glasgow (1937–46).

Trueman's researches, though closely related, fall into three main categories largely resulting from and conditioned by the experience gained from his detailed and original morphological, ontogenetic and phylogenetic studies on ammonites. Accounts of the evolution of several families of ammonites were followed by similar studies on gastropods and the lamellibranch *Gryphaea*. Characteristically, Trueman recognized the implications of his palæontological discoveries in terms of their practical application towards a fuller understanding of Jurassic chronology and of their usefulness in zonal subdivision of these rocks in the field. Thus concomitant work described the palæontology of the Lias rocks from Lincolnshire and South Nottinghamshire to Somerset and Glamorganshire.

There followed that part of his work concerned with appreciation of the fundamental conceptions involving genera and species, of populations and of variability, and of the impact of such considerations upon taxonomy. His contributions to the more philosophical aspects of palæontology ranged among other topics, from lineage and orthogenesis, to a reconsideration of the species concept in palæontology, and culminated during his revision of the Coal Measures Non-marine Lamellibranchs (1927) in the application of biometric techniques to a study of variation in fossil communities and to the use of statistical investigations in detailed correlation. Work by Trueman, and others who have since extended his conceptions, has led to radical changes in outlook and added considerably towards evaluation of fundamental processes in evolution.

Trueman's later work dealt with the palæontology and with varied aspects of the stratigraphy of the British Coal Measures. The purely palæontological studies of the Coal Measures non-marine lamellibranchs from South Wales soon enabled him to indicate their practical applications in the identification of coal seams, and resulted in a zonal subdivision of the South Wales Coal Measures in 1927, leading to a suggested correlation of the British coalfields (1933). The detailed application of this zonal scheme to every major British coalfield, and the utilization of the accruing evidence in exploration within coalfields, or during boring for extensions or for new fields, by Trueman, independent workers and by officers of the Geological Survey bear witness to its efficacy. Indeed, this subdivision has formed the accepted method of presentation in all important papers and memoirs since its inception, and has contributed largely to a rationalization of Coal Measures stratigraphy, as summarized by Trueman in his presidential addresses to the Geological Society of London. The publication of a Palæontographical Society Memoir on the Coal Measures non-marine lamellibranchs in collaboration with Dr. J. Weir marks still further an important permanent record of widespread researches which constitute a major contribution to geological science.

Acknowledgment of his work by election to the Royal Society followed in 1942; the Geological Society of London awarded him the Bigsby Medal (1939) and the Wollaston Medal (1955).

Sir Arthur was energetically concerned for the welfare of geological science at all levels and published a number of books, in general illustrated by himself, and which were of interest to the layman, the school pupil or the student. However, his interests and knowledge were considerably more widespread and embraced many aspects of the educational field and of its organization and its contacts with science and industry. This knowledge made him a welcome member of many committees, such as the Elliot Commission on educational problems in West Africa, the Advisory Council on Scientific Policy, and as chairman of the Geological Survey Board.

Those who were fortunate to come under his influence either as students or staff regarded him with respect and affection, for his kindness, integrity and sympathetic understanding made him a friend in whom one felt complete confidence. His charm of manner and keen sense of humour, combined with a remarkably quick grasp of problems and wise judgment in their solution, convinced one of his very personal interest in every member of his department, student and staff alike. No student ever sought Trueman's help or advice in vain. He was always ready to discuss work and ideas and contrived to make all feel their ideas were interesting and their results important. As a leader he was a deep source of inspiration and encouragement, and possessed that inestimable gift of putting a person at ease. His enthusiasm and zeal were combined with a vital and ceaseless energy which he imparted to others; his lucidity of mind and exposition made him a great lecturer and superb teacher, in the lecture theatre, and above all in the field.

This remarkable combination of wide university experience, achievement, leadership, organizing ability and high moral integrity led to his appointment as deputy chairman of the University Grants Committee in 1946, and its chairman in 1948. In this office, at a time of critical importance in the developments of the British university system, Trueman contributed much by his knowledge, influence and wise counsel. Unfortunately, his period of office was limited, for he fell ill late in 1952 and soon afterwards resigned.

During the last years of his life Trueman struggled with great and uncomplaining fortitude against increasing physical disability, his mind alert and active, his sense of humour unimpaired; and during this time, with indomitable spirit he wrote parts of, and edited contributions for, his last book, "The Coalfields of Great Britain", a project which had been in his mind for many years.

Sir Arthur is survived by Lady Trueman and their son, E. R. Trueman. Lady Trueman's companionship, help, understanding and encouragement contributed greatly towards his many achievements, and her unselfish devotion during the later years enabled him to face his disability with great courage.

LESLIE R. MOORE

Prof. Duncan Leitch

THE tragically premature death of Prof. Duncan Leitch at the age of fifty-two, a week after that of his friend and colleague, Sir Arthur Trueman, came as a shock even to those friends who knew of his grave illness.

Leitch was a graduate of the University of Glasgow and served there as assistant and lecturer in geology until, in 1947, he succeeded Prof. T. Neville George in the chair of geology at the University College of Swansea.

Leitch's main scientific work was concerned with the palæontology and stratigraphy of the Coal Measures. He collaborated with me in zoning the

Scottish Coal Measures by the successive assemblages of non-marine bivalves that are fossilized in these rocks. Afterwards he used the zones in elucidation of an obscure section of Coal Measures in Arran, and gave accounts of variation in several groups of these fossils, notably of Lower Carboniferous and Namurian *Naiadites* which are peculiar to Scotland and are doubtless forerunners of the numerous and more widely distributed guide fossils of this genus in the Coal Measures. His most notable work on this line, however, was the admirably detailed biometric description of variation in a community of *Anthraconaia* [*Anthracomya*] from the Central Coalfield of Scotland, prepared with the help of Dr. R. A. Robb, which made an important contribution to taxonomic method in the study of these highly variable animals, and explained various anomalies in their vertical distribution within the Coal Measures.

At Swansea Leitch had established a research team to continue the study of these principles and their application to field-problems, especially in the structurally difficult measures of Pembrokeshire; but his premature death has inevitably deferred the fulfilment of this work.

For several years he was secretary of Section C (Geology) of the British Association.

Leitch was a kindly, friendly man who loved company, an attribute that was reflected in his happy relations with students in laboratory and field. He leaves a widow and young son. J. Weir

---

Sir Richard Redmayne, K.C.B.

Sir Richard Redmayne, who died on December 27, was born at Low Fell, County Durham, in 1865. He was the son of John Marriner Redmayne, of Low Fell—a lover of the fine arts and no mean painter in water colours and a devout Christian: attributes fully inherited by his son. His grandfather, Giles Redmayne, built and endowed Brathay Church in Westmorland and was complimented on its structure by the poet Wordsworth.

Sir Richard served his apprenticeship at the Hetton Collieries under William Armstrong, a famous mining engineer who had been apprenticed to the celebrated John Buddle, the 'father of the Coal Trade' and intimate friend of George Stephenson of locomotive fame. At one period in his training he rose at 2.30 a.m., and walked a mile and a half to the mine, which he descended at 3.30 and came out at 10.30. In the afternoon he attended the office to write reports and do other administrative work. He also studied at the Durham College of Science—now King's College, Newcastle upon Tyne. He became an under-manager and in 1891 left England to undertake mining operations in South Africa. In 1893 he was appointed manager of a group of collieries at Seaton Delaval. On that occasion the Rev. C. H. Boutflower—afterwards Bishop of Tokyo and later of Southampton—wrote as follows:

"Turn on the buzzer, blow the horns, bang all the tubs together!
Let every Gall'way neigh response, each driver crack the leather!
Oh happy day—let Seaton say—and happiest news to tell of all
Dick is become our Manager of Mines at Seaton Delaval."

In 1902 Sir Richard was appointed professor of mining at the University of Birmingham and, writing as one of his first students, I can say that all those who studied under him will honour his memory for his great kindness and the hospitality of his home by the then Mrs. Redmayne, who was the ideal hostess. Sir Richard retired from the chair at Birmingham to become the first H.M. Chief Inspector of Mines at the Home Office, and I was very fortunate in serving him as private secretary for two years. His appointment caused a little jealousy among a few of the then senior inspectors, but the justification of his selection was soon evident. Very early he had to investigate and report upon some of the largest colliery explosions which have occurred in Britain. At that time the late Sir William Garforth had conducted large-scale experiments at Altofts Colliery, where there had been a serious explosion, demonstrating the explosive nature of coal dust and the possibility of neutralizing its nature by the application of stone dust. Sir Richard decided immediately to strengthen the regulations relating to safety and drafted a Bill which became the Coal Mines Act, 1911. This Act, based on practical and scientific knowledge, foresight and common sense, is, at the moment, still in operation. This fact indicates the soundness of its structure. In my opinion this Act was Sir Richard's *magnum opus*. Its enforcement resulted in diminishing rapidly the loss of life from such disasters.

Another potential source of danger existed—the danger of open sparking and shock from the application of electricity in mines; and a committee of experts was appointed to consider the inadequacy of the Electrical Special Rules of 1905. The committee consisted of Sir Richard as chairman, Mr. C. H. Merz and Mr. Robert Nelson, who had been appointed the first H.M. Electrical Inspector of Mines. New rules were established and Mr. Nelson enforced them with tact to the great benefit of the industry.

After the firedamp explosions at the Jamage Pit in North Staffordshire and at Cadeby Colliery in Yorkshire (where the Divisional Inspector and eighty-seven others were killed), which were caused as the result of spontaneous combustion, the Home Secretary set up a departmental committee with Sir Richard as chairman to inquire into the circumstances in which spontaneous combustion of coal occurs in mines, its causes and the means of preventing it, and a Blue Book was issued. A code of rules was afterwards drawn up on the organization for rescue and aid in the case of accidents in mines. Now there are numerous rescue stations and trained men in all the coalfields of Britain.

It is perhaps true to say that no man in his profession has filled so many posts and performed such various duties. Sir Richard was a member of three Royal Commissions. He was chairman of the Board for Mining Examinations for many years and was external examiner in mining for the Universities of London, Birmingham, Wales and New Zealand, and examiner for the Camborne School of Mines, the Board of Education and the City and Guilds of London. Sir Richard was held in such high esteem by H.M. Civil servants that he was elected for thirty-three years in succession as president of the Institution of Professional Civil Servants. He was also a past-president of the Institutions of Civil Engineers and of Mining and Metallurgy.

This appreciation might appear to be overloaded if a complete list of the offices Sir Richard held were given. He had been a director in a number of colliery and other companies and for many years acted as a

consulting mining engineer. He found time, however, to produce text-books on colliery working and management and the valuation and rating of coal and mining properties. He had a wonderful memory, and his book on "Men, Mines and Memories" is a most fascinating and instructive work. In 1914 he was made K.C.B., and in 1918 he became a chevalier of the Legion of Honour; he was also a companion of the Order of St. John of Jerusalem.

Though such a distinguished and highly gifted man, his personal friends will perhaps remember him chiefly for his sense of humour and great personal charm. He married Edith Rose Richards, daughter of Thomas Picton Richards, of Swansea, in 1898; she died in 1942. There were two sons and two daughters of the marriage. One son died as the result of a motor-car accident. The three others survive him. GRANVILLE POOLE

NEWS and VIEWS

Physics at Bedford College, London : Prof. H. T. Flint

THE retirement of Prof. H. T. Flint from the Hildred Carlisle chair of physics in Bedford College, University of London, constitutes a severe loss to the scientific personnel of the University, for he was a man of exceptionally wide interests. Not only was he a most able teacher whose text-book (with B. L. Worsnop) on experimental physics in the laboratory has for decades been a standard work for honours students, but also his contributions to quantum theory, to relativity and to field theories generally have formed a continual stimulus to workers on these subjects. In addition, his training in medicine and the possession of a medical degree have made him a valued referee for numerous bodies requiring advice on medical physics. His colleagues in the University of London are immensely indebted to him for the many administrative duties which he has generously undertaken as chairman of the University of London Board of Studies in Physics and chairman of the Examining Board. A graduate of the Universities of Birmingham and London, much of his life was spent as reader in physics at King's College, London, when the Wheatstone chair was held successively by Sir O. W. Richardson, Sir Edward Appleton and Sir Charles Ellis. His appointment to the chair at Bedford College in 1944 enabled him to use his long-proved abilities, during the difficult post-war decade, for the development of both theoretical and experimental physics at Bedford College to the maximum possible capacity. He leaves Bedford College in the knowledge that he will not be saying farewell to his innumerable friends, who will continue from time to time to seek that advice which has been so freely and generously given in the past.

Prof. H. O. W. Richardson

PROF. FLINT is succeeded by Prof. H. O. W. Richardson, who has held the chair of physics at University College, Exeter, for the past three years. A son of Sir O. W. Richardson, he graduated at King's College, London, and proceeded to the Cavendish Laboratory, Cambridge, where he received the Ph.D. degree for his researches on applications of the cloud-chamber technique to problems in radio-activity. After further research work at King's College and Bedford College in the University of London, he was appointed a lecturer in the Department of Natural Philosophy at Edinburgh under Prof. N. Feather. It was there that he carried out his important theoretical and experimental studies on the β-ray spectrometer. Brought up in the atmosphere of scientific research, possessed of an original and inventive mind and personality, and with wide experience of a variety of laboratories, Prof. Richardson has much to contribute to the development of physics teaching and research at Bedford College.

Editorship of *Discovery* : Mr. William E. Dick

MR. WILLIAM E. DICK has resigned from the post of editor of *Discovery* after just over twelve years in the chair. During that period, scientists and laymen alike have watched the considerable improvements made in that journal, for Mr. Dick has become established as one of Britain's leaders in the presentation and interpretation of science to the public (see also *Nature*, **172**, 1028; 1953). He has now undertaken the editorship of the newly established journal *British Chemical Engineering*, the first issue of which will be published in May (Drury House, Drury Lane, London, W.C.2).

Dr. Anthony Michaelis

DR. ANTHONY MICHAELIS succeeds Mr. Dick as editor of *Discovery*. Dr. Michaelis obtained his degree in chemistry at the Imperial College of Science and Technology. After several years spent in industrial research laboratories, he joined the headquarters staff of British Intelligence Objectives Sub-committee and during the period 1945–48 he edited the series of the Sub-committee's overall reports. He has since specialized in scientific films, and has devoted particular attention to the use of cinematography as a research tool. He is closely connected with the Scientific Film Association, and has served on the executive committee of that organization (see also p. 298 of this issue). At the Bristol meeting of the British Association in 1955 Dr. Michaelis was mainly responsible for organizing the successful scientific 'film festival', during which some forty films were exhibited.

Russell H. Chittenden (1856–1943)

RUSSELL HENRY CHITTENDEN, the 'father of physiological chemistry in the United States', was born at New Haven, Connecticut, one hundred years ago on February 18, 1856, of a family that had emigrated from Kent in 1639. Almost his entire scientific career was spent in the city of his birth. In 1874, when he was eighteen, he was placed in charge of "the first definitive laboratory of physiological chemistry in America for the instruction of students" in the Sheffield Scientific School at Yale University. In the following year he obtained the degree of B.Sc. with a thesis on glycogen and glycocoll in the muscular tissue of *Pecten irradians*, which was published in the *American Journal of Science and Arts*. It was the German translation in Liebig's *Annalen der Chimie* that gained him entrance into Willy Kühne's laboratory at Heidelberg in 1878. Four years later he was appointed professor of physiological chemistry in Yale University (the first

chair of its subject in the United States). From 1898 until 1922 he was director of the Sheffield Scientific School. His most important work was concerned with the protein element in human nutrition in the days when Carl von Voit's dietary standards were generally accepted; as a result of experiments performed during 1902–3 on himself, his colleagues, students and volunteers from the United States Army, Chittenden showed that good health, physical vigour and nitrogenous equilibrium can be maintained on levels of protein intake considerably below those specified by Voit. In 1909 he served on the Remsen Referee Board to report on the toxicity of sodium benzoate in foods, and after the First World War, together with Graham Lusk, he represented the United States on the Inter-Allied Scientific Food Commission in London, Paris and Rome. His best-known books are "Physiological Economy in Nutrition" (1904) and "The Development of Physiological Chemistry in the United States" (1930). Many honours came his way. In 1896 he was elected president of the American Physiological Society, which office he held for a record number of nine years, and in 1906 the first president of the American Society of Biological Chemists. A scrupulously neat person, who possessed an unerring flair for attracting worth-while pupils, Chittenden died at New Haven on December 26, 1943, in his eighty-seventh year.

Lobachevski and Non-Euclidean Geometry

This year marks the centenary of the death of the Russian mathematician, N. I. Lobachevski, on February 24, 1856. He was born in 1793 at Nijni Novgorod, and at the age of eight became a scholar at the Gymnasium at Kazan, where he made remarkable progress in the study of mathematics and classics. When fourteen years of age he entered the University of Kazan and spent the next forty years there, first as a student, then as a professor and finally as rector. Lobachevski played a major part in the development of the University and undertook a great deal of teaching and administration. In spite of this, he was still able to give time to mathematical thought and succeeded in creating a new field of mathematics. For more than two thousand years the question remained unsolved as to whether Euclid's parallel postulate is an independent axiom or can be deduced from other axioms. Lobachevski was the first to settle the question by constructing a non-Euclidean geometry, based on the hypothesis that through a fixed point there is an infinity of lines parallel to (that is, not meeting) a given line. This situation occurs on a pseudosphere. In 1855 "Pangeometry", the completed works of his mathematical life, was published; it was written in French and Russian and had been dictated because of his blindness.

Inland Waterways in Britain

The Minister of Transport and Civil Aviation announced in the House of Commons on February 1 that he has appointed a Committee of Inquiry into Inland Waterways with Mr. Leslie Bowes as chairman. The other members of the Committee are Messrs. J. Corbett, G. C. Godber, H. E. Hopthrow, W. A. Muddell (chairman of the Land Drainage Committee of the River Boards' Association), F. Ritchie (National Parks Commission), M. Rowe and J. Wilson. The Committee will consider and report on the future of the system of inland waterways in Britain and propose any measures necessary to achieve: (i) the maximum economic use of the system; (ii) the future administration of and financial arrangement for inland waterways which cannot be maintained economically for transport purposes, having regard to requirements of public health and safety, and the facilities which these waterways can provide for recreation, water supply, land drainage and dispersal of effluents; and (iii) the conversion of canal sites to other purposes when this is desirable and practicable. The Committee will also consider the present law relating to the closing of waterways to navigation, and make recommendations.

Permanent Exhibition of Scientific Instruments in London

A permanent exhibition of instruments made by a selection of the hundred and forty member firms of the Scientific Instrument Manufacturers' Association of Great Britain was opened on February 9 by Sir Norman Kipping, director-general of the Federation of British Industries. The exhibition is housed at the Association's headquarters at 20 Queen Anne Street, London, W.1, and though not intended to be public, it is open to all those interested in scientific instruments, especially visitors from overseas. Besides being a centre where visitors can see a representative selection of instruments, the display will also serve as a meeting-place for makers and users of instruments in Britain. An extensive catalogue library is being built up. Since it is impossible to give space to all member firms at the same time, a rota system has been worked out so that each member will have a chance to exhibit, and at the same time the character of the display will change constantly. In opening the exhibition Sir Norman said that the output of the British instrument industry is valued at £60 million a year, of which £15 million is exported. Stressing the importance of instruments in all branches of industry, he said that the fact that of the fifty thousand workers in the instrument industry in Britain, two thousand five hundred are engaged on research and development work augurs well for the future.

Shortage of Science and Engineering Graduates in British Industry

A letter sent to Mr. Iain Macleod, Minister of Labour, signed by Sir Norman Kipping, director-general of the Federation of British Industries, reaffirms the concern of the Grand Council of the Federation at the continuing shortage of science and engineering graduates. It not only urges that industry is handicapped by the general shortage, but also refers to the growing effect of the selective deferment from National Service which is granted to such graduates who take up government or government-supported jobs related to national defence; the effect in practice is that these men remain in the same sort of job and are lost to industry indefinitely. The Federation regards the situation as so serious that, while appreciating the difficulties of exempting all science and engineering graduates from National Service, it urges the Government most strongly to grant deferment where requested to all science and engineering graduates with first- or second-class honours degrees who take up employment in industry generally as well as in Government establishments or on government-sponsored projects, and to continue deferment so long as they remain in such employment. It estimates that the entire annual output of

science and engineering graduates in Great Britain is 1·5 per cent of the number of men eligible for National Service, and that for one reason or another some 50 per cent of the latter are never called up.

Babel: An International Journal of Translation

THE first number of *Babel*, an international journal of translation, has appeared, published by the International Federation of Translators, with the support of Unesco, the Director-General of which contributes a foreword (1, No. 1; 1955. Pp. 40. From the Federation, 16 rue Pierre Charron, Paris; 5*s*. an issue, or 17*s*. annual subscription). It represents the results of the first efforts, after the phase of organization, of the Federation, which was founded in 1953. The most important article in the present issue is that of R. W. Sumpelt outlining the general policy of the Federation and its affiliated organizations with regard to scientific and technical translating and indicating some of the problems with which it is proposed to deal in *Babel*. These include the recording of scientific and technical terminology on an international scale; the improvement of dictionaries and other lexicographical aids; and research in semantics and linguistics to decide what terms would be improved by standardization, and whether standardization should further cope with entire patterns of expression and of thought. Questions on costs of translation will also be considered, and, besides authoritative studies on these and other subjects, reports on current activities and meetings of other organizations of interest to the Federation are also invited. The present issue outlines the translation programme of representative works of Unesco and includes an article by Dr. S. D. Limaye discussing some basic aspects of scientific translation in India and the building up of an Indian scientific vocabulary.

British Rainfall during 1953

UNDER the title "British Rainfall 1953" is published the ninety-third annual volume of the British Rainfall Organization and the thirty-fifth as a Meteorological Office publication (M.O. 588; pp. 216. London: H.M.S.O., 1955; 25*s*. net). Each volume in the series summarizes the rainfall measured during a year at more than five thousand stations, many kept by voluntary observers, in Great Britain and Northern Ireland. The year was on the whole a dry one over most of the country, with amounts of less than 20 in. and less than four-fifths of the average over much of England and Wales. Over north-west Scotland, it was rather wet with up to six-fifths of the average. At Pontefract the total was only 15·43 in. against an average of 23·3 in. The low rainfall over England and Wales was due to the winter months at both ends of the year being dry; the summer was rather a wet one. January was notably dry with a general average of only 1·4 in. over England and Wales and was part of one of the driest winters on record. The heaviest fall in one day was one of 6·5 in. on November 26 at Cwm Dyli, Snowdon. Some very heavy falls of rain occurred in the heavy thunderstorms of June 26, on which day at Eskdalemuir, Dumfries, 2·09 in. was measured in half an hour—the heaviest known fall recorded in the country in that period of time—and 3·54 in. in fifty-five minutes; on the same day 1·72 in. fell in fifteen minutes at Nelson, Lancs. Mr. J. Grindley contributes a useful tabulation, county by county, of the very heavy rainfalls observed since 1860 in periods up to two hours. They are those of, or exceeding, the "Noteworthy" category, which ranges from 0·43 in. in less than five minutes to 1·19 in. in two hours. These show the heaviest fall in ten minutes to have been 1·3 in. at Chagford, Devon, on September 23, 1927, in an hour 3·63 in. at Maidenhead, Berks, on July 12, 1901, and in two hours 4·8 in. at Churchstoke, Montgomery, on June 26, 1895.

Psychological Tests for Accident-Proneness and Industrial Proficiency

MEMORANDUM No. 31 of the Medical Research Council, entitled "Psychological Tests for Accident Proneness and Industrial Proficiency" (pp. 30. London: H.M.S.O., 1955; 2*s*. net), is a reprint of the Industrial Health Research Board reports (Nos. 38, 55, 68, 74 and 84) on accidents, and its appearance is very welcome. The author of the summa y, E. G. Chambers, has studied this problem with the late Prof. Greenwood, Miss E. M. Newbold and Eric Farmer for many years. He notes in the introduction that the investigations reported have extended over fifteen years and have involved more than four thousand subjects and the use of more than thirty different tests. The object of the study was to discover what relationship existed between the test scores of the subjects tested and the recorded accidents. It was hoped that some idea would be gained of the measurable psychological qualities involved in proneness to sustain accidents, with the ultimate practical object of choosing tests to help in the selection of workers for dangerous occupations. Whenever possible, records of industrial efficiency were obtained so that the effect on the proficiency of selection for accident-proneness could be demonstrated. The reports give details of the tests, together with the inter-relations of the tests and their prognostic value, and the present memorandum is a summary of the main conclusions described in the five reports beginning in 1924. No new material is incorporated, and the data are not treated in any new way. Of course, since the publication of these reports, statistical techniques have improved and now the experiments would be planned differently; but a fairly extensive knowledge of recent work makes one realize that the present-day techniques have done little to increase our knowledge. The subjects tested included dockyard apprentices, naval ratings, London and provincial bus-drivers and various groups of trainees. The tests included sensori-motor, æstheto-kinetic, mental and intelligence, physiological, and nervous stability tests. Details of the tests and the precautions taken are given. The outbreak of war in 1939 terminated this research.

Statistical Review of England and Wales

THE General Register Office has recently issued the "Text Volume" of the "Registrar General's Statistical Review of England and Wales for the Year 1952" (pp. 256, 8*s*. net) and the "Medical Tables, Part 1", for 1954 (pp. 375, 12*s*. 6*d*. net). (Both published by H.M.S.O., London.) There are few changes in the presentation of the tables: the most important is the inclusion of tuberculosis notifications in the table relating to notifiable diseases, data which have hitherto only been given in the annual reports of the Chief Medical Officer to the Ministry of Health. There have also been minor changes in the method of classifying hospitals for the chronic sick, which may affect the comparability

of local death-rates. The text for 1952 consists of the usual commentary on population movements in that year. There were no violent changes to report: fertility remained at a stable level, and the concentration of childbearing in the early years of marriage continued. The report brings out the remarkable increase in the married population; in the age-groups 15–19, 20–24 and 25–29 the proportion of women who were married exceeded that in 1938 by 83, 49 and 21 per cent, respectively. An interesting report on marriages by method of solemnization shows that 13·6 per cent of the 1952 religious marriages were celebrated according to Roman Catholic rites against 9·1 per cent in 1934, the last year for which figures were collected. Civil marriages as a proportion of all marriages increased from 28·4 per cent to 30·6 per cent in the same period. The mortality section of the text includes a detailed analysis of cancer mortality.

Vitamins: Memorial Essays to Sir Edward Mellanby

The January issue of the *British Medical Bulletin* (12, No. 1; from the British Council Medical Department, 65 Davies Street, London, W.1; 15*s*.) is a memorial number to Sir Edward Mellanby, the late secretary of the Medical Research Council. As the article on him and his work by Sir Charles Harington, director of the National Institute for Medical Research, so clearly shows, his death deprived British medicine of one of its most influential figures. The number consists of a series of essays on the vitamins, written by experts, which were originally planned by a committee with Sir Edward as chairman, and he himself intended to contribute to it. Now it appears as a memorial to him—a fitting memorial, for it was in the field of vitamins that Sir Edward did such notable work. It is fitting, too, that one article describes the work of the Accessory Food Factors Committee and Mellanby's influence on the work of this Committee. It is impossible to select, from a list of sixteen articles, all written by leading authorities, any that excel the others. The whole issue is valuable; and those interested in any way in vitamins will find that the summaries given of recent work, and the bibliographies that accompany each article, are sources of information which will add to their understanding of a volume of work that is now so extensive that few, if any, can follow all its many aspects and applications. An excellent photograph of Sir Edward, taken in Lucknow, accompanies the number.

Recording of Animal Sounds: Conference in Pennsylvania

The commercial development of tape recorders during recent years has fostered a great deal of scientific research in the recording of sounds made by animals. Unfortunately, the comparison of results by different workers is very difficult: the printed word in a journal is obviously inadequate; the physical analysis of sounds into 'pictures' has little meaning to biologists, and it is not practicable to convert the picture back to the original sounds for retesting; and even the exchange of actual tapes between workers may be useless if the associated machines are of different types. To make a start on these problems a conference will be held during April 16–19 in the United States at the Pennsylvania State University, at which it is hoped to reach agreement on acceptable procedures for recording animal sounds and start a repository of tapes. The first day of the conference will be devoted to reports of research on animal behaviour in which sound-recording techniques have been used, given by the following: Prof. Donald Griffin (Harvard University), Dr. R.-G. Busnel (Laboratoire de Physiologie Acoustique, France), Prof. F. Möhres (University of Tübingen) and Prof. R. J. Pumphrey (University of Liverpool). The remaining days will be devoted to informal discussions on recording techniques and standards. Further information on the conference can be obtained from Prof. H. Frings, Department of Zoology, University Park, Pennsylvania.

University of London: Appointments

Dr. D. R. Cox, visiting research professor in the University of North Carolina, has been appointed to the University readership in statistics tenable at Birkbeck College.

The title of reader in the University of London, in the subjects indicated, has been conferred on the following in respect of the posts that they already hold: Dr. E. J. Harris (biophysics), University College; Dr. Leonard Saunders (pharmaceutical chemistry), School of Pharmacy; Dr. John Sutton (geology), Imperial College of Science and Technology.

Royal Astronomical Society: Officers

The following have been elected officers for 1956 of the Royal Astronomical Society: *President*, Sir Harold Jeffreys, Plumian professor of astronomy in the University of Cambridge; *Vice-Presidents*, Dr. A. Hunter, Dr. J. Jackson, Prof. A. C. B. Lovell, Dr. R. A. Lyttleton (*Geophysical Secretary*); *Treasurer*, Prof. L. M. Milne-Thomson; *Secretaries*, Prof. C. W. Allen, Prof. H. Bondi; *Foreign Secretary*, Sir Harold Spencer Jones.

Announcements

Dr. Claude E. Shannon, research mathematician at the Bell Telephone Laboratories, Inc., has been appointed visiting professor of electrical communications at the Massachusetts Institute of Technology. He will be associated with the Institute's Research Laboratory of Electronics, and will lecture on advanced information theory, based on his recent research at the Bell Laboratories. Dr. Shannon's work in mathematical theory has led to the development of maze-solving machines, and more recently he has been studying problems in probability, such as the design of reliable machines consisting of unreliable components.

The Ergonomics Research Society is arranging a symposium on "Human Factors in Road Transport", to be held in the University of Bristol during April 16–19. The first session will be a general one, though most of the papers will deal with some aspect of visibility, and the second and third sessions will be devoted to driver behaviour and physiological aspects, respectively. The fee for the symposium is 5*s*. for members of the Society and 35*s*. for non-members. Accommodation can be booked at the Manor Hall, one of the University halls of residence. Further information can be obtained from H. Murrell, The Miners' Arms, Priddy, Wells, Somerset.

Erratum. The article on "Structure of Semi- and Non-crystalline Materials" in *Nature* of January 21 contains a reference to a paper by Dr. E. J. W. Whittaker (p. 122, col. 2, line 5 from bottom); in this reference, for "chrysolite" read "chrysotile".

THE NUFFIELD FOUNDATION

REPORT FOR 1954–55

THE tenth report of the Nuffield Foundation, covering the year ended March 31, 1955*, the first year of its third quinquennium, has been published, and records that allocations from income totalled £681,397 during the year, a figure only exceeded when, in 1952–53, the Foundation made its second large five-year allocation to the National Corporation for the Care of Old People. Expenditure for research and experiment within the United Kingdom was maintained undiminished at £445,079, in the year 1954–55 more than a quarter of the expenditure on grants was spent on helping research workers and students overseas. While during 1943–49 this expenditure averaged about £53,000 a year, during 1949–54 the average was £120,000; the report notes that the Foundation's contribution to date of just over £1 million to travelling and research grants and other projects in the British Commonwealth overseas may be the largest private contribution from Britain to the finance of organized academic and professional relations within the Commonwealth, and it also expresses the Foundation's hope that other private resources may be available to enter a field where the opportunities are so great and so rewarding.

Grants within the United Kingdom during the same twelve years have included £875,000 for medical research (including £295,000 for rheumatism); £586,000 for biological research; £614,000 for research in the physical sciences; £684,000 for projects in the social sciences; £37,000 for architectural studies; and £32,000 for agricultural research. Grants for the care of the elderly and research on problems of ageing have totalled £970,000; for fellowships and scholarships for residents of the United Kingdom, £292,000; and for miscellaneous projects, £277,000.

For the year under review, the projects overseas have taken the largest single share (£133,732) of the year's grants, including the creation of a new unit at the University College of East Africa, Kampala, for research into education in Africa; the building of new halls of residence for students at the Imperial College of Tropical Agriculture, Trinidad; £20,940 over four years for Prof. L. C. Beadle's programme of research on tropical swamps; research in Africa which necessitates the participation of trained non-European research workers; marine biological studies in South Africa; and assistance to the newly formed *Journal of the Anatomical Society of India*. The second largest share (£112,541) went to biological studies in the United Kingdom, and more than half of these grants were renewals or additions to earlier ones. Grants to medical research in the United Kingdom totalled £106,560, nearly half of this, including £22,060 from the Oliver Bird Fund, being for research into rheumatism, while fellowships, scholarships and similar awards accounted for £102,566, nearly two-thirds being for residents overseas in the Commonwealth.

A feature of this report is the evidence that the projects which the Foundation has fostered are coming to fruition, and this is to be found in the tribute paid to the important scientific results which have now come from two earlier grants through the University of Oxford. In August 1955 Dr. Dorothy Crowfoot Hodgkin, as a result of the detailed X-ray analysis of crystals of complex compounds that are of interest in biology and medicine, conducted by her small research team, was able to announce the solution of the crystal structure of a degradation product of vitamin B_{12}, and with it the structure of almost the whole of the chemically unknown part of the molecule. The second result is the discovery, made by Dr. R. G. Macfarlane and associated workers as part of a long-term programme on blood-diseases, of a method of extracting highly concentrated anti-hæmophilic globulin from ox and pig blood for the treatment of hæmophilia, injection of which into hæmophilic patients undergoing surgery, skin-grafting and dental extraction invariably completely prevented abnormal bleeding.

Of the seventeen grants for biological research made during the year, about half the total was for new grants, more than half of which were for research in departments of botany. New grants include £16,000 over five years to the University of Liverpool for studies on the chemistry and microbiology of the polyphenolic types in the soil; £15,000 over three years to the University of Oxford for research under Dr. Honor Smith into certain immunological reactions of the central nervous system; and £6,000 over three years to University College, London, for electron-microscopical studies of the central nervous system. A grant of up to £3,000 over three years has been made to the University of Oxford to assist Prof. C. D. Darlington's work on chromosomes and £2,500 over three years to the University of Southampton to enable Prof. W. T. Williams to engage two additional research workers for his study of etiolation in plants. Additional grants include a further £5,005 over the remaining two years of the university quinquennium in support of Prof. J. F. Danielli's investigations at King's College, London, into the nature of differentiation and the factors controlling it, particularly the relative importance of nucleus and cytoplasm; a further £22,500 for four years to the Nuffield Institute for Medical Research, Oxford, to support Mr. H. B. Parry's research on pregnancy toxæmia of sheep; and a further £1,550 a year for the two years 1955–57 and £235 for equipment to the University of St. Andrews for Prof. H. G. Callan's work on comparative endocrinology.

On the recommendation of the Department of Scientific and Industrial Research, the Foundation has decided to spend up to £35,000 to finance a pilot aeromagnetic survey to ascertain whether the extensive use of such surveys in Great Britain would be justified on economic and technical grounds. A grant of £7,200 over three years has been made to Birkbeck College, London, to support Dr. A. D. Booth's work on mechanical translation, and the Foundation is also providing a sum of up to £7,000 over three years to the University of Oxford to meet the running cost of the Archæological Research Laboratory, after which, it is understood, the University is prepared to take over the whole recurrent cost. A progress report from the Foundation's Division for Architectural Studies records that

* The Nuffield Foundation. Report for the Year ended 31 March, 1955. Pp. 125. (Tenth Report.) (London: Nuffield Foundation, 1955.)

during 1954 a pilot study on the use of space, services and equipment in research laboratories was made in two of the major establishments of the Agricultural Research Council and that the first appointments have been made to the two postgraduate fellowships in architecture, tenable within the Division.

The major part of the year's grants for medical research went for further fundamental research in the chronic rheumatic diseases, and the Oliver Bird building, which houses the clinical and laboratory research of the Rheumatic Unit, Northern General Hospital, Edinburgh, was completed and opened during the year. New grants for medical research included £17,500 (including £1,250 for capital expenditure) to the Frenchay Hospital, Bristol, to finance current expenditure over five years on Dr. R. M. Norman's research into the causes of certain types of mental deficiency; and £5,000 to the University of Durham for a survey of Tyneside industry by the Nuffield Department of Industrial Health. A further grant of £5,000 over three years was made to University College Hospital Medical School, London, for the continuation and development of Dr. N. Smyth's work on the application of electrical techniques in medicine, in particular for the study of the womb in childbirth, which has already made a contribution to the safety of mother and infant; and an additional £4,000 was offered to the Oxford Regional Hospital Board to enable the project on the relation between physique and behaviour, with special reference to psychiatric disorders, at the Warneford and Park Hospitals, to continue for another year.

Most of the allocation for social research and experiment was to complete the grant of £100,000 additional to the permanent endowment of Nuffield College, Oxford. New grants include £2,500 a year for three years for a bibliographical programme in the social sciences, aimed at the production of good bibliographical tools by elaborating a series of consistent schemes or recipes which will facilitate the provision of abstracts or bibliographies in the social sciences. It will include a survey in London of the adequacy of existing library and research facilities for social scientists. Another new grant of £3,300 a year for three years was made to the University of Oxford in support of Lady Hall's empirical research into the distributive trades; £2,600 a year for five years has been given to the Shoreditch Project Committee for launching an experiment in preventive social work, and a research scholarship of £1,250 a year for three years to Dr. V. L. Allen for his proposed study at the London School of Economics and Political Science of the role of trade unions in Britain during the past thirty-five years. A final grant of £3,000 has been made to the Institute of Statistics, University of Oxford, for completion of the national survey of incomes and savings.

A grant of £8,000 over four years was made to St. Bartholomew's Hospital Medical College, London, to support Prof. K. J. Franklin's research into the physiology of ageing, and one of £5,000 over two to two-and-a-half years to Lord Beveridge to enable him to carry further his history of prices and wages in England. A miscellaneous project of some wide interest is the inquiry into the best means of assisting the learned periodicals. A sum of £43,750 over five years has been allocated for this purpose; in the meantime the British Academy and the Royal Society have been informed that a sum of £8,000 a year will be available over the next five years to be spent on the support of primary journals in primary subjects, and that up to a further £750 a year will be available for the payment of any necessary professional advisory fees on such questions as printing economy, publication and distribution. The distribution of the grant will be entrusted to two special committees, one for periodicals in the humanities, and one for scientific periodicals. With the taking over by the Kent County Council of the Mersham reception centre for deprived children, established with the help of the Caldecott Community, the balance of the Foundation's grant has been allocated to establish an experimental remedial education centre.

Of the eighteen new projects in the Commonwealth overseas, besides those already noted may be mentioned: £5,200 to the University of Adelaide for studies, by electrophoresis diffusion, of substances and systems of biological interest; £6,800 to the Australian National University, Canberra, towards the first three years cost of a five-year research project on post-war immigration into Australia; £3,200 to the University of Sydney in support of a small medical and anthropological expedition to the high country of New Guinea; £3,700 over three years to the Cawthron Institute, Nelson, for research on symbiotic association in New Zealand plants, with special reference to their nutrition and growth on soils poor in certain nutrients; and £3,000 a year for three years to the University of Otago for a combined investigation there and at Canterbury Agricultural College, Lincoln, into endocrine problems of lactation.

During the year twenty-two awards were made to residents of the United Kingdom and forty-three to residents of the Commonwealth overseas (including the first five Canadian study-grants for short-term research in the United Kingdom). Eleven awards were made under the scheme of visiting lectureships and special grants, open to residents of the whole Commonwealth, and fifteen appointments were made in 1954 under the Royal Society and Nuffield Foundation Commonwealth bursaries scheme.

SCIENCE AND TECHNOLOGY IN WESTERN GERMANY

THE brief review of the scientific recovery of Western Germany, compiled by Mr. K. H. Lauder, scientific attaché to the British Embassy in the Federal Republic and issued by the Department of Scientific and Industrial Research*, is of great interest both to the scientist and technologist. It outlines in the first place, very briefly, the action taken by the United Kingdom authorities from 1946 onwards to assist the rehabilitation of academic science in Western Germany—action with which the Department of Scientific and Industrial Research has been associated from the start, primarily by financing the preparation of reports by German scientists; nearly thirty such reports, which are listed in an appendix to this review, were later issued in Britain as "Sponsored Research (Germany) Reports". To this work a generous tribute is paid in a letter from Prof. Otto Hahn, president of the Max-Planck-Gesellschaft zur Förderung der Wissenchaften, Göt-

* Department of Scientific and Industrial Research. A Brief Review of Science and Technology in Western Germany. Pp. viii+103. (London: H.M.S.O., 1955.) 4s. net.

tingen, and the review itself shows the success which has attended this action.

Secondly, the review gives a concise but authoritative picture of the present organization of science and technology in Germany and the way in which, following the almost complete collapse of scientific and technological activity, this has been rebuilt on modern lines. Its successive chapters, dealing with physical sciences and technology, electrical engineering and electronics, engineering (except electrical), chemical sciences and technology, metals, biological and medical sciences, agriculture and forestry, and productivity in industry, facilitate an accurate appreciation of the strength and weakness of Western Germany's position in world technology, outside the restricted or prohibited fields of aerodynamics, radar and nuclear science; and it shows how serious a challenge Western Germany offers to British technology now that the post-war phase is over and Western Germany has emerged as a sovereign power. Thirdly, while it is in no way intended as a reference book, the review brings together in convenient form much useful information on universities, technical and scientific institutions in Western Germany, research expenditure and the like.

Damage to research institutions in Western Germany at the end of the Second World War is estimated to have averaged 61 per cent of the total destruction, equipment was non-existent and scientific research and technological development were at a standstill. From the nucleus of scientists collected at Göttingen in 1946 has grown the Max-Planck-Gesellschaft, which to-day is probably the most significant non-industrial research organization in Western Germany, and, except in fields highly significant in defence, the recovery of science is now practically complete. On an average the rebuilt research establishments and the buildings and equipment of the many new research institutes appear to be better than corresponding ones in Great Britain. Staffing, however, has been a major problem, though the rebuilding of research institutes has been accompanied by an intensive programme of education in the expanded universities and colleges of technology, including generous subsidies for travel abroad, to repair the gaps in scientific knowledge and man-power.

Government expenditure on scientific research in academic and independent research organizations is estimated at more than DM. 600 million during the past financial year and is still increasing, while industry is spending a like sum in its own research establishments, estimated at about 5 per cent of turnover for the chemical industries and 1 per cent for engineering: expenditure by the Farbenfabriken Bayer, by the Badische Anilin- und Soda Fabrik and by the Farbwerke Hoechst is estimated at about DM. 40 million each, and the former is completing a fourth new laboratory for research and development at Leverkusen at a cost of DM. 15 million. Siemens und Halske (now reported to be the third largest electrical undertaking in the world) has recently completed a new research and development laboratory at Munich to accommodate twelve hundred research workers. Considerable effort is devoted to fundamental research, and the mounting cost of research is encouraging co-operative research.

The review suggests that the gap between scientific research abroad and that in Western Germany is narrowing and that in some fields, such as electron microscopy, Germany is abreast, if not ahead, of the rest of the world. The chemical industry has put a very large amount of money into research during the past three or four years, and Western Germany has also gone far to organize a healthy growth of its chemical engineering industries. A research association has been set up and long-term plans have been made for the provision of research institutes, each concentrating on specific fields. The first of these, at Aachen, is already operating, and others are planned at Darmstadt, Munich and Karlsruhe. Much attention is being given to rationalization, and several teams have visited the United States to study American methods in automation. After allowing for the heavy social burdens carried by industry, it is estimated that the real cost of labour is 90 per cent of that in the United States. Some fundamental research has already been carried out in aerodynamics, radar and nuclear science, and now that these fields are open, extensive programmes of applied research have been planned.

It is probable that, although somewhat elaborate, the organization of science and technology in Western Germany is now better than ever. The major scientific bodies are as follows: the Deutsche Forschungsgemeinschaft, or German research council; the Stiften-Verband für die Deutsche Wissenschaft e.V., a society of influential men, chiefly industrialists, concerned with collecting money from industry for the support of science; the Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V., a re-creation of the Kaiser Wilhelm society; the Deutsche Verband Technische-Wissenschaftlicher Verein; the Arbeitsgemeinschaft Industrielles Forschungsvereinigungen, co-ordinating the activities of twenty-three industrial research associations; the Nordsheim Westfälische Arbeitsgemeinschaft für Forschung; and the Deutsche Gesellschaft für Dokumentation. The work of the Deutsche Forschungsgemeinschaft is described at some length. Besides its research programme, for which the Federal Government's current grant runs at DM. 10 million a year, it makes an annual grant of DM. 1 million to about thirty-five scientific libraries on condition that their literature is available to scientists generally and also makes grants for the printing of *Habilitationsschiften* (probationary treatises embodying the results of original research) and *Fortsetzungswerke* (revised or supplementary works), particularly those that may have a very limited circulation.

An increasing tendency to contract research is noted; two and a half years ago the Battelle Memorial Institut für Deutschland e.V. was established at Frankfurt am Main, beginning work in December 1953, and the establishment of an agency for contract research, known as the Vermittlungsstelle für Vertragsforschung e.V. is planned. Although Western Germany has no government department specifically charged with looking after scientific research, most ministries support research in some form or other, and grants proposed in the Federal Budget for 1955 for scientific research and technological establishments totalled more than DM. 164 million, as against DM. 75·9 million in 1954. In 1954, moreover, taking into account contributions from State governments, from district councils and municipalities and from other donors, the total contribution for non-industrial scientific research, including scientific teaching, totalled DM. 663·8 million compared with DM. 391·6 million in 1950. Independent calculations indicate that the average cost of research in Western Germany per head of staff is about DM. 9,000, and about four times this figure

per head of qualified staff. Among Government research institutions may be mentioned the Physikalisch-Technische Bundesanstalt, which conducts research on standards of physical quantities and on equipment, for example, where safety is involved, and the Bundesanstalt für Mechanische und Chemische Materialprüfung.

There is no exact equivalent in Germany of the Royal Society, the body most nearly corresponding to it in pre-war days, the Deutsche Akademie der Wissenschaft in Berlin, being now under the control of the East German Government. There are, however, four academies of science in Western Germany; and, with the founding of the Johannes Gutenberg University at Mainz in 1946 and of the Free University of Berlin in 1948, and the conversion, in 1945, by addition of a humanistic faculty, of the College of Technology, Berlin-Charlottenburg, into the Technische Universität, Berlin, there are now in the Federal Republic of Western Germany and the Western Sector of Berlin sixteen universities, eight 'Technische Hochschulen' (colleges of technology with university status), and eight other colleges with university status but more highly specialized. The Technische Hochschulen aim to achieve a blending between teaching and applied research, and much of the undergraduate research is undertaken in industry itself. Many industrial research institutes are associated with these Technische Hochschulen, either as part of a teaching department or as separate research institutions.

At the end of the Second World War the German patent system had ceased to exist; but after protracted discussions a Western German patent office was re-established in October 1948, moving later to new premises in Munich, and in 1953 the number of patent applications was about 7 per cent higher than in the whole German Reich in 1938, the trend being towards a further increase. The emphasis on applied research is growing. Even in general terms this is an impressive achievement; and, of all the achievements in particular fields that are summarized in the review, it is difficult to select examples that illustrate more emphatically the extent to which Western Germany is prepared to make the scientific research effort upon which to-day the economic and political strength of any country depend. It might be added, however, that Western Germany can again supply the bulk of its own requirements for scientific instruments and that these are finding a growing market abroad, that the Institute of Radiation and Nuclear Physics at the University of Bonn plans to instal a 30-MeV. synchro-cyclotron, that there are estimated to be eight thousand ultrasonic generators in Western Germany, and that there has been intensive development of the electron microscope which is widely used as a research tool. In electrotechnology there have been notable developments in power technology, in the field of heavy equipment, in electrical instruments of all kinds and in electronics, particularly the development of computers.

In mechanical engineering the traditional interest in machine-tool design has been maintained, and major developments are proceeding in railway transport. Gas turbines are being investigated for heavy road vehicles and stationary power plants, and extensive use of newly developed building aids and techniques has enabled the building industry to achieve a building-rate second only to that of Sweden. Much attention has been given to road research, while in chemical industry the Gelsenkirchen firm, Bergwerke A.G., has commenced production of dicyclopentadiene based on raw benzole, and the Krupp Kohlenchemie G.m.b.H. the Fischer–Tropsch synthesis of hard paraffins. Rheinpreussen A.G. has extended its plant for propyl and butyl alcohol to a capacity of ten thousand tons annually, and Farbenfabriken Bayer, Leverkusen, is continuously improving its methods of producing dyestuff intermediates and general textile chemicals, including preservatives, detergents and emulsifiers, and is taking a great interest in automatic processing. Germany now claims second place in world plastics production, and a new research centre at Darmstadt is investigating the structure of plastics and setting up methods of testing. In the biological and medical sciences the impact of new physical techniques is evident, and some of the most significant researches are those on the fundamental chemical processes of cell metabolism, biochemical mechanisms and chemotherapeutics. Much effort is directed to the solution of Germany's difficult agricultural problems, and particular attention has been paid to soil humus, potato cultivation and systemic insecticides.

ELECTRON MICROSCOPY OF FIBRES

During January 3–4 the Electron Microscopy Group of the Institute of Physics held what was originally intended to be a small specialist conference on the electron microscopy of textile and other industrial fibres, in the Department of Textile Industries of the University of Leeds. The response, in attendance and papers offered, showed that the experiment was amply justified. In all, more than sixty delegates, eight from overseas, attended, and eighteen papers were read and discussed. There were three half-day sessions, devoted to techniques, protein fibres and cellulose fibres, respectively.

In the first session O. C. Wells (Cambridge) described the scanning electron microscope developed at Cambridge, and gave examples of its use for studying fibre surfaces. Whether the scanning microscope or the reflexion microscope (which was used by J. A. Chapman (Manchester) in a study of abraded nylon fibres) will ultimately 'corner' this particular field was the subject of much speculation; neither is yet capable of the resolution of the conventional transmission instrument, but each has certain advantages. On the whole, opinion seemed to be that the added complication of the scanning instrument would, at present, prevent its competing effectively with the other, but further developments will be eagerly awaited by microscopists.

Replication techniques were discussed by D. G. Drummond (Manchester) and by L. Oster, J. Sikorski and H. J. Woods (Leeds). Both schools find two-stage replicas most satisfactory in practice; Drummond has been working with the polystyrene/carbon process[1], but the Leeds workers still favour their silver/SiO technique, which they are using to study merino wool and nylon surfaces. Drummond stressed the desirability of reducing preparatory techniques to a routine capable of being followed by unskilled assistants; but the Leeds team seemed to imply that this was crying for the moon, since in their experience replication is an art which can only be learned by experience.

Ultra-thin sectioning is at last becoming a major tool in fibre microscopy, and a number of papers were devoted to investigations in this field. A. O. T. Charles and J. Sikorski (Leeds) have studied the polymerization of embedding methacrylates, an important process in the preparation of specimens for sectioning; they discussed the advantages and drawbacks of the technique they favour, namely, polymerization by ultra-violet light. P. Chippendale (Manchester) showed sections of wool, rayon and nylon fibres and illustrated how skin and core effects can sometimes be detected in the man-made fibres. Although some details of the cellular constitution of the cortex could be seen in his wool sections, the results emphasized that normal wool has only slight variations in electron density between histological components in the cortex. G. E. Rogers (Cambridge) presented two papers which described what were technically the most beautiful micrographs shown at the conference. His sections of the wool follicle, although enormously superior in resolution, could be compared for clarity with the best results of the histologists using light microscopes, who seem to be left with few distinctive tools other than stains and the polarizer. Enthusiasm for sectioning must, however, be tempered by the fact that the examination of normal mature natural fibres by this technique has not yet produced any very remarkable results, and it remains to be seen whether the argument, that sectioning is the only correct technique because it does not involve degradation, is still valid. A point of view which found support was that the use of sectioning or disintegration in conjunction with controlled chemical treatments is still one of the most fruitful fields of investigation.

In the second session Sikorski and Woods pointed out the difficulty of reconciling the macrofibrillar type of structure observed in the follicle of a wool fibre with the occurrence of extended microfibrillar sheets in disintegrated fibres. They suggested that keratinization might involve the stabilization of a microfibrillar texture which is not yet obvious in the matrix regions of the cortical cell in the follicle, and the uniplanar linking together of the microfibrils to form sheets. They reported that different methods of attacking the disulphide links in keratin (for example, by reduction or oxidation) may lead to distinctive disintegration products when specimens are prepared for examination by the electron microscope. M. S. C. Birbeck and E. H. Mercer (London) described sections of hair in their study of the cuticle layer. They now believe, on the basis of histochemical experiments, that the endocuticle is non-keratinous in character; they also emphasized the importance of the cell membranes both in the cuticle and the cortex of the fibre. An interesting suggestion was that in human hair, where the cuticle cells have large overlaps, the epicuticle seems to be tucked in beneath the scale which it is covering; this feature is less obvious in wool fibres.

D. Burton, R. Reed and M. J. Wood (Leeds) discussed the hydrothermal shrinkage of leather, a phenomenon of great technological importance in the control of leather manufacture. In the early stages of hydrothermal treatment, tanned collagen fibrils swell and assume a helical form, while the cross-striations come closer together. Similar structures, with left- or right-handed twist, also occur during the heat treatment of native collagen fibrils. The fibril is therefore considered to be a cross-helical array of polypeptide chain bundles, these being of variable chemical composition and hence sensitivity towards heat. Tanning forms cross-links between the two helical arrays, while shrinkage involves the relative movement of the cross-helical structures.

K. M. Rudall (Leeds) showed pictures of the thin ribbon-like units of the ootheca of the praying mantis. Structurally, these protein sheets are important in that they possess a modified α-type structure with preferred orientation in the transverse plane; although the polypeptide chains are parallel to the length of the ribbon, a feature of the electron micrographs is the appearance of striations inclined to the length at an angle of approximately 22°. A. B. Meggy and J. Sikorski (Leeds) described microcrystals of the two forms of polyglycine [see also p. 326 of this issue]; the most notable micrographs showed that polyglycine II crystallizes in hexagonal laminæ, in agreement with the trigonal structure proposed recently by Crick and Rich[2]. Growth spirals are observed in the crystals, and the growth steps correspond roughly, but not exactly, with the mean chain-length. Although both forms of polyglycine can absorb considerable quantities of dye (for example, orange II), there is no direct evidence either from X-ray or electron microscope studies as to where the dye is located in the structure.

The final session started with a paper by E. Frei and R. D. Preston (Leeds), who showed micrographs of serial sections of conifer wood tracheids, in which the spiral angle of the microfibrils could be observed. They confirmed that the structure of the various layers in the cell wall is substantially the same as had been suggested by previous X-ray and polarization microscope results; in particular, the basic structure of the outer layer of the secondary wall is a flat spiral, although microfibrils running at a steeper pitch are also present. Somewhat similar results were obtained by H. W. Emerton (Kenley), who is concerned with the outer layers of the cell wall because of their importance in connexion with paper-making. In his striking pictures of softwood tracheids obtained with the reflexion microscope, however, he observed only the macrofibrils, and this provoked a discussion as to why his severely treated beaten fibres should show such remarkable macrofibrils, whereas the (presumably) more gently treated material of Frei and Preston should give remarkably clear microfibrils. There is a curious antiparallel here with the results previously mentioned for keratin, where disintegration was claimed to lead to microfibrils and sectioning to macrofibrils. To make matters more obscure, S. Asumnaa (Stockholm) showed sections of laboratory pulps impregnated with heavy-metal atoms, in which little in the way of a fibrillar structure could be seen at all. Some of her preparations did reveal a striated structure, and there were differences attributable to the effects of various chemical treatments.

R. H. Marchessault (Marcus Hook, U.S.A.) and B. G. Rånby (Upsala) have extended the work on the hydrocelluloses produced by the action of mineral acids on cotton and wood, which reduce the microfibrils to elongated rod-like particles, and attempted to correlate the lengths of the particles with the degree of polymerization (osmotic value). A problem which they had to solve was to produce well-dispersed samples; they found sulphuric acid preferable to hydrochloric acid as a hydrolysing agent, while the concentrated acid, low-temperature technique of Mukherjee and Woods[3] gave better dispersions than the dilute acid, high-temperature process of Rånby and Ribi[4]. Sulphation of the surface

layers of the particles was suggested as a reason for this.

A long paper on the fine structure of viscose rayon was presented by P. Kassenbeck (Paris). Among other topics, he considered the possibility of obtaining crimped fibres by bilateral heterogeneity, the influence of spinning conditions on the fine structure, and the question of a surface skin on the fibres. He suggested that the skin usually observed in the light microscope is covered by another very thin superficial layer. Can we expect now another battle of nomenclature?

Much credit for an interesting and stimulating conference is due to Dr. Sikorski, the local organizer.

[1] Bradley, D. E., Inst. Phys. Electron Micr. Group Conf., Glasgow (1955).
[2] Crick, F. H. C., and Rich, A., *Nature*, **176**, 780 (1955).
[3] Mukherjee, S. M., and Woods, H. J., *Biochim. Biophys. Acta*, **10**, 499 (1953).
[4] Rånby, B. G., and Ribi, E., *Acta Chem. Scand.*, **3**, 649 (1949).

PHYSICS OF ATMOSPHERIC CLOUDS

DURING January 4–5 the Physical Society and the Royal Meteorological Society held a joint conference on cloud physics in the Department of Meteorology, Imperial College of Science and Technology, London. It was so arranged that on each day four speakers outlined recent developments in a particular branch of the subject; unusually generous periods were allotted, and needed, for discussion.

On the first day Mr. B. J. Mason (Imperial College) gave a short introductory talk on the scope of the cloud physics to be reviewed, which extended from the laboratory studies of the microphysical processes affecting the formation and growth of cloud particles, to the properties of the extensive cloud systems responsible for cyclonic rains. He was followed by Dr. C. Junge (United States), who spoke on the nuclei of atmospheric condensation, a subject on which much of our present knowledge is due to Dr. Junge's own researches, mostly made since the Second World War, first in Germany and more recently in the United States. He described how the composition and size distribution of the particles of atmospheric aerosol have been investigated, over the enormous range of sizes from a radius of about 10^{-7} cm. to about 10^{-3} cm. The smaller of these particles are the most numerous, usually occurring in concentrations of about 10^4/cm.^{3}, and are those predominantly precipitated in conventional nucleus counters (the 'Aitken nuclei'). Particles with diameters exceeding about 10^{-5} cm. are usually found in size distributions characterized by the relation $dn/d(\log r) = \text{const.}/r^3$, where dn is the concentration of particles in the range of radius dr. The largest particles, the giant nuclei, with radius exceeding 10^{-4} cm., occur in concentrations of less than 1/cm.^{3}, but are important in cloud formation, for they produce a small proportion of unusually large cloud droplets which may readily grow to raindrops by settling through and sweeping up the remainder (the 'coalescence process' of rain formation). The giant nuclei are composed mainly of sea-salt derived from sea-spray, and have been extensively sampled by Dr. A. H. Woodcock (United States) and Dr. H. Dessens (France), who also took part in the conference. Dr. Junge discussed the composition of the somewhat smaller nuclei, which produce the bulk of cloud droplets, and showed that the important constituents are ammonium and sulphate radicals. He particularly emphasized the importance of generating processes and of coagulation and precipitation processes in maintaining the characteristic size-distributions, and the need for more study of the trace materials present in the air in similar concentrations, but in the gas phase. The discussion became a debate on the proportions of cloud droplet nuclei which are produced by sea spray; the general opinion was that it is their size, rather than number, which makes the sea salt nuclei important.

Dr. H. Weickmann (United States) reviewed information on the constitution of non-precipitating clouds, dividing them for this purpose into stratified and convective clouds. He gave special attention to the relations between the droplet size distribution, the total concentration of condensed water, and the visibility in clouds. He mentioned that the local conversion of supercooled clouds into crystal clouds by seeding is useful as a kind of marking which gives insight into ordinarily invisible turbulent and other air motions in the clouds. Illustrations of the peculiar crystal forms found in ice clouds were drawn from a remarkable series of high-altitude flights in an open-cockpit aircraft which Dr. Weickmann made in Germany during the Second World War. He finally mentioned the iridescent colours, and by inference the droplet constitution, of the rare stratospheric mother-of-pearl clouds, the temperature of which is thought usually to be as low as −80° C. This provoked discussion and alternative inferences from the physicists, who now believe that liquid water freezes spontaneously at about −40° C.

In the afternoon of the first day, Mr. B. J. Mason, speaking rapidly, gave an impressive account of the growth of research upon the nucleation of supercooled water—the initiation and the growth of ice crystals. He discussed the role of homogeneous and heterogeneous nucleation of supercooled droplets, and concluded that in the atmosphere they have predominant importance at temperatures near and below −40° C., and above about −30° C., respectively. He supposed that the effective particles at the higher temperatures are wind-raised silicates. Much more efficient ice nuclei can be made from the iodides of lead and silver, whereas practically all other chemicals can be shown to be inactive. Mr. Mason then reviewed the growth of ice crystals by condensation, and remarked especially that the preferred habit changes with temperature: down to −4° C. hexagonal plates predominate; between −4° C. and −8° C., and below about −20° C., prisms occur; while between about −8° C. and −20° C. plates and stars are found. In the laboratory, crystals of startling shape have been grown by varying the temperature: for example, long prisms have been made to sprout upwards from the corners of a hexagonal plate. In the discussion, some speakers challenged the view that only the temperature controls these changes in crystal habit, and Prof. J. D. Bernal doubted if they could be explained by considering only equilibrium states. Dr. Dessens mentioned a small sausage-shaped (presumably organic) type of particle which has been identified as an active ice nucleus in the atmosphere at temperatures below −[illegible] C. Mr. J. S. Turner (Australia) announced a recent experiment which shows that the loss of nucleating activity to which silver iodide smokes are subject in the daylight does not occur at night.

Dr. R. Braham (United States) reviewed the physics of precipitation mechanisms, and emphasized

the lack of knowledge of the processes of collision and coalescence between small droplets, which hinders correct appreciation of the importance of the coalescence mechanism of rain formation. He showed that showers form purely by this mechanism in the Caribbean, and that the mechanism still operates in the larger clouds of the eastern United States, whereas the Bergeron–Findeisen ice-crystal mechanism might be the more important in the arid south-western States. These challenging statements and striking flight-observations provoked a lively discussion.

On the second day, Mr. F. H. Ludlam (Imperial College) pointed out that the partitioning (into micro-, macro- and synoptic-physics) of cloud studies, though convenient, must not be made too rigid. It is particularly important that meteorologists (especially dynamicists) should develop the difficult studies of individual clouds, in order that the meteorological conditions within which the microphysical processes operate should be better understood. He illustrated the links which must be sought between the main divisions of the subject by describing some features of convection clouds in the lower troposphere (cumulus), the upper troposphere (cirrus), and the stratosphere (noctilucent clouds). It has been found in Sweden that showers form in cumulus if their tops exceed a rather well-defined level which varies from day to day, and at which the temperature varies from −4° C. to about −25° C. It seems that the coalescence mechanism is responsible for both the shower formation and the extensive production of crystals in the cloud tops. Studies of the other clouds show that there must be a source of atmospheric nuclei, not only at the Earth's surface, but also in the high atmosphere. Examinations of the outer solar corona and the zodiacal light support the hypothesis that cosmic dust settles into the atmosphere at a rate sufficient to provide practically all the nuclei present in the upper troposphere, and to provide concentrations of about 100/cm.^{3} of Aitken nuclei near the ground. The implications of such a universal pollution of practically invisible particles (diameter about 10^{-5} cm.) need careful consideration.

Mr. J. S. Sawyer (Meteorological Office) discussed the properties of the great layer-cloud systems which are associated with cyclones and fronts. The computations of the vertical motion in these atmospheric disturbances, which can now be made with the help of machines, are incapable of resolving internal details that can be deduced from rainfall records and flight investigations. Probably the formation of these cloud systems plays a significant part in cyclone development, for their presence reduces certain braking-effects due to the stable stratification of the atmosphere. Mr. Sawyer described new models of the vertical structure of frontal clouds, based mainly on observations of the Meteorological Research Flight.

On the final afternoon Prof. J. S. Marshall (McGill University) spoke on radar studies of clouds and precipitation. He described the use of millimetre radar, which can 'see' a high proportion of non-precipitating clouds, and of centimetre radar to obtain a three-dimensional representation of snow streamers, which are a characteristic feature of about half of the winter snowfall in Canada. These streamers fall from self-propagating convective cells. He also reviewed new information on the formation of 'bright-band' precipitation echoes, radar evidence of the importance of the coalescence mechanism in shower formation, radar 'angels' at a sea-breeze front, the peculiar hook-shaped echoes associated with tornados, and the spiral-band echoes received from tropical cyclones.

The last contribution was from Dr. T. W. Wormell (Cambridge) on the generation of electricity by thunderstorms. He summarized existing evidence on the distribution of electricity in thunderclouds, and on the rate of charge re-separation in the intervals between lightning discharges. After outlining the classical and more recent theories of charge generation, he remarked that strong electrical activity is found only in clouds containing ice particles. The most recent theory of charge generation, due to Reynolds in New Mexico, attributes it to collisions occurring between ice crystals and small hailstones which are growing by sweeping up supercooled droplets, and which have a surface temperature a degree or two higher than the crystals owing to the release of the latent heat of fusion. This promising theory is now being developed quantitatively; but it is likely to have competition, for a new paper is expected from C. T. R. Wilson, and a proposal by Vonnegut that the large cumulus is for macrophysical reasons an influence machine is attracting attention.

The conference was notable for the very substantial participation of overseas physicists and meteorologists, and for the enormous range of the topics raised. The expansion of cloud physics has been so great that it is now impossible to describe the progress of research other than cursorily in a two-day meeting, even if no reference is made to the possibilities of weather modification which have been such a strong spur to recent work. It was unfortunate that a smog reduced the attendance of the conference; but the audience each day exceeded one hundred and fifty, and its members must have been impressed with the present scope of the subject and the vigour with which its many problems are being attacked.

F. H. LUDLAM

BRITISH COUNCIL

TWENTY-FIRST ANNIVERSARY REPORT

THE twenty-first anniversary report of the British Council*, which includes a congratulatory message and a tribute to the services of the Council from the Prime Minister, covers the year 1954–55 and is unusually brief. Acceptance of the broad principles of the Drogheda Report was only announced by the Government in December 1954, but the effect of the new policy, which included the devotion of £100,000 to the expansion of the Overseas Information Service (including the Council) in 1954–55 and again in 1955–56, has already been felt. For the first time in seven years the Council's grant-in-aid was not reduced, and negotiations were commenced with the Treasury for the establishment of an amalgamated Council service, for the improvement of conditions of service, and for the introduction of a satisfactory pensions scheme. The Council's work and establishment in several Western European countries were reduced, and the small cultural establishment in Germany was disbanded; university teachers were supplied to the Universities of Berlin (Technical University), Göttingen, Hamburg and Mainz. Additional allocations were made for the cultural activities of the

* Report on the Work of the British Council, 1934–1955. Pp. vi + 121 + 6 plates. (Twenty-First Anniversary Report.) (London: British Council, 1955.) 2s. 6d.

Brussels Treaty Organization (Western European Union and the Council of Europe). The Council's representation in New Zealand was withdrawn, and its establishments in Australia and Ceylon were closed; but work in Persia was resumed.

The number of students who were met on their first arrival from overseas reached the record total of 4,164, 3,771 being Colonial students, while new and better premises for this work among students were acquired in Aberdeen, Belfast, Edinburgh and Oxford. Two awards were made to university professors for short visits to the United Kingdom, and seven for visits to other Commonwealth countries, while forty-two travel grants were made to university teachers or postgraduate workers for study visits to the United Kingdom, ten for study visits from the United Kingdom and two for study visits between overseas countries. There were also forty-nine short visits to the United Kingdom universities and forty-nine visits to foreign universities. Some twenty-nine lecture tours and advisory visits overseas were arranged in science, medicine, agriculture and engineering, and twenty-one in education, sociology, philosophy and law; besides tours and exhibitions, the Council supplied about 82,000 books to Council and Council-associated libraries and secured 6,921 reviews of British books in overseas periodicals. Of the lecture tours arranged, 33 per cent were in medicine and science, and 25 per cent in education, while of the 1,488 film prints distributed in fifty-five countries, 216 were medical and 220 scientific and technical.

Most of the report is occupied by a historical review by Sir Harold Nicholson of the inception of the Council and the development of its work from 1934 to 1955, including a critical appreciation of that work. This is followed by an appreciation of its present activities by the new director-general, Sir Paul Sinker, and there is also an appreciation of Sir Ronald Adam's work by Sir Philip Morris. Since the end of the Second World War the Council has arranged programmes for 35,726 overseas visitors, mainly professional people or technicians, including many who have come under United Nations or Colombo Plan programmes; but the proportion of such visits financed wholly or in part by the Council has fallen from 66 per cent in 1945–46 to 16 per cent in 1954–55.

LONG ASHTON RESEARCH STATION

REPORT FOR 1954

A CONSIDERABLE number of papers on various aspects of disease control is to be found in the report for 1954 of the Agricultural and Horticultural Research Station, Long Ashton, Bristol, which has recently been published*. Such a concentration in no way disturbs the general efficacy and breadth of the report, as it relates to other aspects of fruit culture and fruit products. It serves, rather, to integrate the results of several workers, thus giving a special, as well as a general, significance to an annual report of progress.

* University of Bristol. The Annual Report of the Agricultural and Horticultural Re earch Station (The National Fruit and Cider Institute), Long Ashton, Bristol, 1954. Pp. 207+13 plates. (Long Ashton: The Station, 1955.) 15s.

On the question of materials for disease control, G. V. Coles, J. T. Martin and R. J. W. Byrde have investigated the fungicidal properties of coal-tar distillates against *Ceratostomella fimbriata*, causing mouldy rot of newly tapped bark of the rubber tree. The predominating effect of the phenol fraction in determining fungicidal efficiency was confirmed by chemical analysis and bioassay. R. J. W. Byrde and A. T. K. Corke found that sporulation of *Nectria galligena* on apple cankers was reduced for about eighteen months, following treatment with 0·3 per cent phenyl mercury chloride. Burgundy mixture has been used for a long period of years, but E. Somers has demonstrated that the mixture 10 lb. copper sulphate, 14 lb. sodium carbonate, 100 gall. water, gives the best tenacity on potato foliage, when applied against blight. Post-dormant sprays of DDT and BHC kill some predators of the red spider mite; H. G. H. Kearns, N. G. Morgan and A. H. Wilkins have found that eggs of the mite can be controlled effectively by spraying with 0·05 or 0·02 per cent chlorbenside (*p*-chlorbenzyl *p*-chlorphenyl sulphide). Applications were made at the pink-bud stage of Worcester Pearmain apples, and were not effective at earlier stages.

Specifications for two light-weight small-power sprayers are given by H. G. H. Kearns and N. G. Morgan. They use 34-c.c. and 70-c.c. petrol engines, and deliver 8 and 19 pints/min., respectively, both at 75 lb./sq. in. There is considerable interest in the relative efficacy and operational economy of small-volume air-flow spraying. Messrs. Kearns and Morgan have also found the method effective against potato blight, but the same authors, with R. W. Marsh, record that apple scab control using lime sulphur or captan required more air-flow applications to be as effective as large-volume spraying. Small-volume sprayings accentuate the need for studies on spray-droplet size and distribution. C. G. L. Furmidge has two papers on this question; one of them describes field methods in which droplets are estimated as impressions in magnesium oxide, or as stains on glass, plaster of paris or various paper surfaces. Methods for the assay of captan deposits are described by J. T. Martin and J. A. Pickard, while the distribution of copper and DDT deposits are discussed in relation to the method of application by N. G. Morgan and J. T. Martin. Finally, R. W. Marsh considers results on apple scab control over eleven years with a view to the formulation of a modern spray policy for the fruit grower. Results from 1954 are marshalled to the same end by R. J. W. Byrde, G. M. Clarke and C. W. Harper. The general conclusion from both these papers appears to be that captan and phenyl mercury chloride, among the newer fungicides, are most likely to find places in the normal spray schedule for apple varieties which are 'russeted' by lime sulphur.

The mycological side of plant pathology is represented by a paper by A. T. K. Corke, who finds that inoculations with mycelium of the bitter rot fungus *Gloeosporium perennans* on apple branches produced cankers at all times of the year. Inoculations with spore suspensions, however, were generally successful only in November and December. From the section of pomology, R. R. Williams, continuing an earlier study, has described a further eleven varieties of perry pears from Herefordshire and Gloucestershire. The same author has a final report on yields and orchard behaviour of thirty-two varieties of cider apples grown as bush trees during 1950–53, and pollen

requirements of these particular apples have been studied. A. I. Campbell has found that Brompton and Common Mussel plum stocks are suitable for the four new plum varieties Teme Cross, Severn Cross, Frome Cross and Thames Cross, all raised at Long Ashton. A report by D. L. Abbott shows that 2 : 4 : 5-TP at 40 p.p.m. was effective as a fruit-ripening agent on Worcester Pearmain apple when sprayed on the leaves rather than on the fruit. Barbara A. Rake has studied the influence of basal wounding and size of shoot on the rooting of hard-wood cuttings of the gooseberry.

Two crop failures on acid soils are described in the section on plant nutrition. One (by C. Bould and E. G. Bradfield) was of apples, in soil of *p*H 3·9–4·2, and the other (by W. Plant, of the Agricultural Research Council Unit of Plant Nutrition) was of carrots at *p*H 4·5.

The vintage quality of cider produced from bush trees has been evaluated by L. F. Burroughs. Many samples were of excellent quality, but the locality at which the fruit was grown influenced the composition of the juice and the vintage quality. F. W. Beech describes two methods of producing bottled cider free from deposit, either by sterile filtration before bottling or pasteurization after bottling. Alice Crang and Margaret Sturdy present continuing progress reports on the preservation of vegetable varieties by canning and freezing, and on fruit varieties by bottling and freezing.

The annual report is produced to the usual high standards of printing and illustration, and as a final instance of its comprehensiveness, there is a paper on statistics by G. M. Clarke and A. T. K. Corke. This considers sources of variability in sampling black currants for leaf spot. It leads to the conclusion that a redeployment of available labour would have brought greater precision if more bushes had been sampled with fewer shoots per bush. This is a good example of the team work and integration which are evident from all the work of the Station.

JOHN GRAINGER

RELATIONSHIP BETWEEN LENGTH OF DAY AND GEOTROPIC RESPONSE IN SEEDLINGS

By E. DOROTHY BRAIN

SENSITIVITY and response to gravity in fern fronds[1] and various species of seedling[2] have been shown to be influenced by the stage in development rather than the size or growth-rate of the plant organ. Sensitivity to light has also been found to vary with the age and stage of development of the seedling of *Avena* at the time of illumination[3]. It is therefore significant that seasonal variation in response to gravity which has been recorded for *Lupinus polyphyllus* seedlings[4,5] can be correlated both with the rate of development of the seedling and the distribution of statolith starch in the developing plant. Experiments have shown that both response to gravity and efficiency of the statolith apparatus decreased in the winter months in plants grown entirely in the dark and under normal conditions. If the plants were given longer daily periods of light in the winter by illumination with a 25-watt 'Mazda' electric bulb, their rate of development was increased and they became more reactive in response to gravity in the later stage of the seedlings' development, when response in control plants was falling off. The pattern of their geotropic response became similar to that for the summer when activity is at its optimum. In summer, when the day was lengthened by giving 2 or 2·5 hr. extra light artificially, the response to gravity was raised above that of the controls, and with 4 hr. extra light the increased response was more marked. Comparisons were based on the percentage of plants in a series which responded to a stimulus (that is, period of horizontality) of 20 min., which was known to be the presentation time for the *Lupinus polyphyllus* seedling.

An examination of the distribution of statolith tissue, at different times of year, in seedlings grown in the dark and in the light, has shown a similar variation. There was found to be an optimum condition of the statolith apparatus in seedlings for the summer which corresponded with the optimum for geotropic activity in the later stage of development when the cotyledons were opening and the epicotyl beginning to develop.

An examination of the statolith distribution at this stage has also been made in seedlings which were given extra light in the winter and summer months. The methods used were the same as those described in a recent publication, and the seedlings were classified into the following groups according to: (*a*) The extent of statolith tissue in the hypocotyl: (1) from the cotyledonary node to the collet; (2) from the cotyledonary node half-way down to the collet; (3) at the apex or in the cotyledonary petioles; (4) having no statoliths. (*b*) The number of statoliths seen in transverse section at the upper part of the

Table 1. PERCENTAGE OF PLANTS

	No. of plants	Extent of statolith tissue (1)	(2)	(3)	(4)	Number of statoliths (1)	(2)	Size of statoliths (1)	(2)
Nov. Control	17	23·52	52·94	23·52	0·0	70·58	29·41	47·04	52·94
,, 6·5 hr. extra light	6	83·33	16·66	0·0	0·0	50·0	50·0	50·0	50·0
Jan. Control	15	13·33	13·33	66·66	6·66	60·0	33·33	46·66	46·66
,, 6·5 hr. extra light	15	26·66	26·66	40·0	6·66	46·66	46·66	20·0	73·3
June Control	3	100·0	0·0	0·0	0·0	100·0	0·0	100·0	0·0
,, 2·5 hr. extra light	4	100·0	0·0	0·0	0·0	100·0	0·0	75·0	0·0
,, 4·0 hr. extra light	4	100·0	0·0	0·0	0·0	100·0	0·0	75·0	0·0

hypocotyl: (1) more than four; (2) less than four. (c) The size of the individual statoliths in statocytes at the upper part of the hypocotyl: (1) diameter 4·9μ; (2) diameter 2·5μ or less. The numbers found in each group were compared as percentages of the series and the results are shown in Table 1.

It will be seen that plants given extra light in the winter had a higher percentage with the maximum amount of statolith tissue than controls. In June no effect of extra light was shown on the extent of statolith tissue; but in January and June there was a tendency for the statoliths to be smaller in plants which had received extra light. A quantitative examination of the statolith apparatus in some fifteen species of seedlings made by Hawker[2] demonstrated a very close correlation between the volume of statolith tissue and the degree of sensitivity to gravity. Seasonal variation in geotropism in *Lupinus polyphyllus* gives another example of this. In winter, when development is slow, geotropic response and the amount of statolith tissue declines before the epicotyl develops. By increasing the period of light received daily the epicotyl development is hastened and geotropic response and statolith efficiency are also increased. In summer, when normally development and geotropic response are at their maximum, extra light raises the response to gravity in the later stage of development.

It therefore seems evident that it is the effect of light on the rate of development of the seedling which is the factor responsible for the changes in geotropic response which have been observed.

[Nov. 18

[1] Waight, F. M. O., *Ann. Bot.*, **37**, 55 (1923).
[2] Hawker, L. E., *Ann. Bot.*, **46**, 121 (1932).
[3] Thompson, B. F., *Amer. J. Bot.*, **37**, 4, 284 (1950).
[4] Brain, E. D., *New Phytol.*, **51**, No. 1, 49 (1952).
[5] Brain, E. D., *New Phytol.*, **54**, No. 3, 292 (1955).

SPONTANEOUS CHROMOSOME BREAKAGE IN ENDOSPERM

By Dr. A. RUTISHAUSER
University of Zurich
AND
L. F. La COUR
John Innes Horticultural Institution, Bayfordbury, Hertford, Herts

RECENT studies have shown that endosperm nuclei may show a higher incidence of spontaneous chromosome breakage than those in any other plant tissue. A possible exception is the nuclei in the tapetum, where conditions are not particularly favourable for study. Its incidence in endosperm nuclei seems to be related to special genetic and hybrid conditions. For example, mass chromosome breakage was found in endosperms of a lily hybrid, and similarly a high degree of breakage was observed in endosperms obtained from self- and cross-pollinations of *Ranunculus auricomus*[1].

It was concluded by Brock[2], from a study of endosperms obtained from crosses between hyacinth varieties, that chromosome balance had a marked effect on breakage conditions. He found breakage was slight in endosperms from diploid–diploid crosses, but became progressively greater in endosperms from diploid–trisomic and diploid–triploid crosses.

The present investigation is largely concerned with an attempt to evaluate the effect of hybridity involving nuclear and cytoplasmic interaction on chromosome behaviour in endosperm tissue. To obtain this we have used endosperms from intergeneric fertilizations using *Paris quadrifolia* $2n = 20$, *Trillium cernuum* and *T. grandiflorum*, both $2n = 10$. This material is particularly favourable since in the hybrid endosperms we can readily distinguish at least four of the five *Trillium* chromosome types from the chromosomes of *Paris* by a difference in heterochromatin content (Fig. 1). With cold treatment only the *Trillium* chromosomes show weakly-staining and therefore readily distinguishable blocks of heterochromatin (Fig. 2)[3]. In *T. grandiflorum* it is sometimes the *A*- and in *T. cernuum* the *C*-chromosome which shows no such distinguishing feature.

To reveal the heterochromatic segments, plants with developing seed pods received a four to five day treatment at just above 0° C. prior to fixation and preparation of the endosperm for chromosome studies[4]. Because of slow development, cold treatment was not given until twenty to forty days after pollinations were made.

Spontaneous chromosome breakage was found in endosperms from all three kinds of crosses made. It was high in endosperms of *Paris* ovules fertilized with *Trillium* pollen, and low in the reciprocal cross *T. grandiflorum* × *Paris*. Ovule development was poor

Table 1. Frequency and Distribution of Spontaneous Chromosome Breakage in *Trillium* Chromosomes* from Hybrid Endosperms of *Trillium* × *Paris* and *Paris* × *Trillium*

Cross	*A*			*B*			*C*			*D*			*E*			Total		
	Normal	Broken	%broken	Normal	Broken	%broken	Normal	Broken	%broken	Normal	Broken	%broken	Normal	Broken	%broken	Normal	Broken	%broken
T. grandiflorum × *Paris*	36	—	—	41	—	—	38	—	—	37	1	2·6	38	1	2·6	190	2	1·0
Paris × *T. grandiflorum*	87	14	13·9	112	15	11·8	101	7	6·5	107	6	5·3	47	93	66·4	454	135	22·9
Paris × *T. cernuum*†	47	41	46·6	67	20	23·0				83	4	4·6	48	40	45·4	245	105	30·0

* The unequal frequency of chromosome types is mainly due to chromosome loss.
† The *C*-chromosome is not readily distinguishable.

in this latter cross, but sufficient endosperms were examined to show that the difference in breakage, which is of an order of about 20 : 1, is a valid one (Table 1).

It can be noted that the low frequency of breakage in *Trillium–Paris* crosses is not significantly higher than that in endosperms obtained from *Trillium–Trillium* crosses (unpublished data from examination of more than two thousand nuclei in fifty crosses).

A particularly interesting feature was that breakage is confined to *Trillium* chromosomes. We must emphasize that none of the broken chromosomes could have been transmitted through the pollen, because many of the hybrid endosperm nuclei contained normal unchanged *Trillium* chromosome sets.

Breakage occurs both in eu- and hetero-chromatic segments. Unfortunately, an exact analysis of initial breakage is not possible, since secondary changes arising from breakage of bridges at anaphase are superimposed on initial breakage, which we believe occurs spasmodically throughout endosperm development in this material. Breakage of chromosomes is followed by reunion to give dicentrics, rings, translocation and sister reunion, all of which occur in our material. Our analysis at metaphase is based on these changes, together with changes disclosed by visible loss or gain of segments. This is made possible by the pattern of eu- and hetero-chromatic segments.

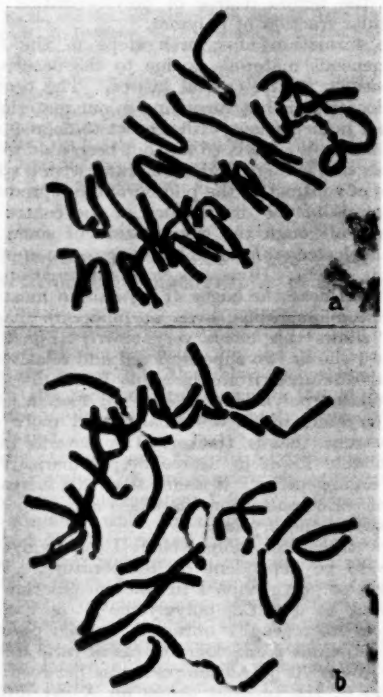


Fig. 1. Microphotographs of metaphases from endosperms of the cross *Paris quadrifolia* × *Trillium cernuum* showing 25 chromosomes. The five *Trillium* chromosomes show heterochromatic segments revealed by cold treatment. In (*a*) a *Trillium A*-chromosome shows loss of part of an arm; in (*b*) again loss in an *A*-chromosome together with a dicentric chromosome. × 1,200 *Note.* The embryo-sac development in these species is of the '*Allium* type' and the endosperm nuclei are therefore triploid in constitution. Endosperms from *Paris* × *Trillium* contain 20 *Paris* chromosomes and 5 *Trillium* chromosomes and in the reciprocal cross 10 from each parent

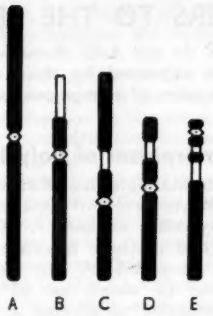


Fig. 2. Diagrammatic illustration of the five chromosome types in *Trillium grandiflorum* showing relative lengths of eu- and hetero-chromatic segments. Heterochromatin in outline, euchromatin in black and centromeres in outline with a dot

Some interesting features emerge when we study the distribution of breakage between chromosomes and in individual chromosomes. First there is an extremely unequal distribution of breakage between chromosomes. In the crosses between *Paris* and *T. grandiflorum*, most of it occurs in the *E*-chromosomes, and clearly this is not related to chromosome length or heterochromatin content (Fig. 2). Secondly, within the *E*-chromosomes of this cross, we find distribution of breakage is non-random.

If we divide the *E*-chromosome into seven parts, namely, short arm, centromere and eu- and hetero-chromatic segments, we find breakage in the long arm is relatively greater in segments distal to the centromere, and somewhat disproportionate in eu- and hetero-chromatic segments according to length (Fig. 3). Although it is perhaps unwise to speculate unduly on the significance of these observations, nevertheless it is tempting to invoke centromere interference as favouring the distal distribution.

Fig. 3. Expected values based on a random distribution

It is clear, at least from the *Paris–Trillium* cross, that hybridization can influence the rate of spontaneous chromosome breakage in endosperm nuclei. It might be thought that the difference in response of *Paris* and *Trillium* chromosomes to change of cytoplasm is against the view that the *Paris* cytoplasm plays a predominant part in influencing breakage in *Trillium* chromosomes. Alternatively, we might suppose that the interaction of two genetic systems leads to special conditions favouring the induction of chromosome breakage by changes in cell metabolism. At the moment, because of insufficient evidence, we can make no decision as to which of these views we most favour.

One of us (A. R.) is the recipient of a grant from the Swiss National Fund. [Sept. 23

[1] Brock, R. D., *Heredity*, **8**, 409 (1954). Rutishauser, A., *Mitt. Nat. Ges.* Schaffhausen, **25**, 1 (1954).
[2] Brock, R. D., *Heredity*, **9**, 199 (1955).
[3] Darlington, C. D., and La Cour, L. F., *J. Genet.*, **40**, 185 (1940).
[4] Rutishauser, A., and Hunziker, H. R., *Arch. J. Klaus-Stiftg. f. Vererb. forschg.*, **25**, 477 (1950).

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Dimorphism of Polyglycine

The two crystallographic forms of polyglycine observed by Meyer and Go[1] have recently been re-investigated by other workers[2–4]. This problem has also been studied in these laboratories.

Polyglycine prepared by the polymerization of diketopiperazine in water at 60°–180° C., or by direct polymerization of glycine at 140° C.[5], shows strong X-ray reflexions at 3·45 A. and 4·4 A.; this is polyglycine I[3]. It is similar to the material obtained by the polymerization of anhydrocarboxyglycine in hot pyridine[1] or in ethyl acetate[2], and its structure, proposed by Astbury[2], resembles that found in the polyamides[6].

If polyglycine I, prepared as in ref. 5, is dissolved in saturated calcium chloride solution and precipitated at 20° C. by the addition of water, the product shows reflexions at 4·15 A. (vs) and 3·1 A. (m); this is polyglycine II[3]. A structure for this material has recently been proposed by Crick and Rich[4], in which the polymer chains are packed hexagonally.

Our preparations of polyglycine II, when examined under the electron microscope, showed crystals almost hexagonal in shape. Slow precipitation of the last, most soluble, portion of our preparation gave hexagonal crystals as in Fig. 1; with lithium bromide[1] the regularity of the crystals was less perfect. The crystals show growth steps, similar to those observed by Dawson and Vand[7] for homogeneous substances, though the formation is less perfect.

The number-average degree of polymerization of our preparation, in bulk, was 12·2, although that of the fraction which gave Fig. 1 may be lower. The expected height of successive steps would be about 40 A. for a degree of polymerization of 12·2; this is somewhat higher than the value estimated from the apparent length of shadows in the electron micrographs. This discrepancy is caused by the necessarily low accuracy of the latter method, and uncertainty as to the actual degree of polymerization of this particular fraction of polymer.

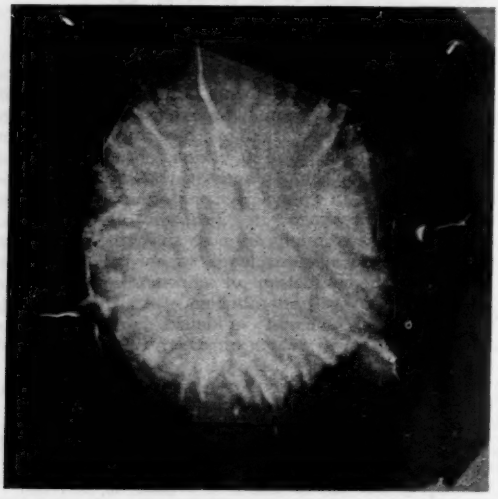


Fig. 1. Polyglycine type II (ref. 3); two overlapping hexagonal crystals. × 6,000

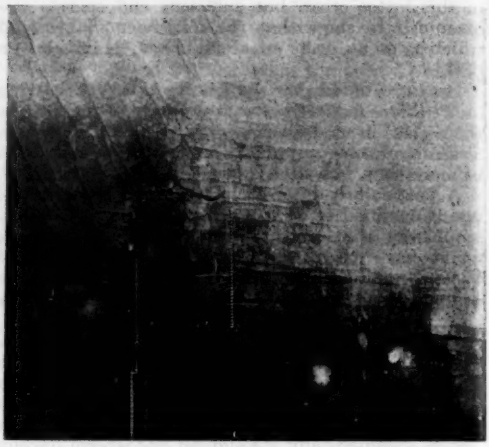


Fig. 2. Same as Fig. 1; details of terrace structure and lattice dislocations. × 30,000

The formation of growth steps in the case of homogeneous materials is due to the occurrence of dislocations in the crystal lattice. The occurrence of dislocations is not surprising in our material, since it is not homogeneous with respect to degree of polymerization. We have, so far, not been able to obtain crystals thin enough to demonstrate, with a sufficient degree of contrast in the photographic reproductions, the details of the dislocations in the centre of the crystals, although the examination of some of our original electron micrographs confirms the appearance of such effects. However, close examination of the fine detail near the edges of crystals in most of our electron micrographs, even at moderate magnifications, shows this effect very clearly (Fig. 2).

Fig. 1 shows two superimposed and relatively thin crystals obtained from the same fraction. The unfractionated polymer, degree of polymerization 12·2, gives crystals which are smaller and more opaque to electrons, that is, thicker. The material in Fig. 1 is probably lower in degree of polymerization and more homogeneous; it seems that this increases the rate of condensation on the edges and reduces it on the face of the crystal.

The transition polyglycine I $\rightleftharpoons$ polyglycine II seems to be dependent on temperature. When a solution of polyglycine I in calcium chloride is precipitated at 100° C., polyglycine I is recovered; electron micrographs obtained during preliminary work show flat parallelograms (axial ratio 0·9, acute angle about 70°). At temperatures between 100° C. and 60° C. the product shows an X-ray diffraction pattern intermediate between I and II, with a rather marked change at 60°, below which type II polymer is obtained. On the other hand, if type II polymer is dissolved in calcium chloride solution and precipitated at 100° C., type II polymer is recovered. It seems that there is a tendency for the polymer to be precipitated in the form in which it went into solution, presumably due to the persistence of crystal

nuclei. If type II polymer is heated to 140° C. in water, it is partially converted into type I. We believe that polyglycine has a transition temperature in the region of 60° C. The type II polymer obtained at 100° C. was probably a metastable preparation.

The importance of the thermal equilibrium in the mechanism of the formation of dislocations has been stressed by Frank[8], and we believe that further work on such effects may prove to be of great value in the studies of protein denaturation.

The density of polyglycine was determined with a specific gravity bottle at 22·5° C. and 65 per cent relative humidity, using toluene as displaced liquid.

Polyglycine (type)	I	II	I
Degree of polymerization (number average)	8·4	10·6	12·2
Density (gm./c.c.)	1·469	1·475	1·486

Thus there is an increase in the density with increasing value of the degree of polymerization. The structure of polyglycine I requires a density of 1·56 gm./c.c.[2], and the structure proposed by Crick and Rich[4] for polyglycine II 1·54 gm./c.c.

A. B. Meggy
J. Sikorski

Textile Chemistry and
Textile Physics Laboratories,
Department of Textile Industries,
University of Leeds.
Dec. 2.

[1] Meyer, K. H., and Go., Y., *Helv. Chim. Acta*, **17**, 1488 (1934).
[2] Astbury, W. T., Dalgleish, C. H., Darmon, S. E., and Sutherland, G. B. B. M., *Nature*, **162**, 596 (1948). Astbury, W. T., *Nature*, **163**, 722 (1949).
[3] Bamford, C. H., Brown, L., Cant, E. M., Elliott, A., Hanby, E. W., and Malcolm, B. R., *Nature*, **176**, 396 (1955).
[4] Crick, F. H. C., and Rich, A., *Nature*, **176**, 780 (1955).
[5] Meggy, A. B., *J. Chem. Soc.* (In the press).
[6] Bunn, C. W., and Garner, E. V., *Proc. Roy. Soc.*, A, **189**, 39 (1946).
[7] Dawson, I. M., and Vand, V., *Proc. Roy. Soc.*, A, **206**, 555 (1951).
[8] Frank, F. C., *Disc. Faraday Soc.*, **5**, 67 (1949).

Temperature Effects in the Paper Partition Chromatography of Sugars]

The maintenance of a constant and uniform temperature within the apparatus is universally recognized as an essential for the production of satisfactory paper partition chromatograms. The effect of the temperature at which the chromatograms are made has, however, been comparatively little studied.

Consden, Gordon and Martin[1] reported variations in the R_F values of amino-acids chromatographed over the temperature-range 7–25° C. Hough, Jones and Wadman[2], who chromatographed sugars at 20° C. and 37° C., reported that at the higher temperature there was faster movement, improved definition of the spots and higher R_F values. Counsell, Hough and Wadman[3] also showed that in the chromatography of sugars the R_F values were influenced by the temperature of working, and that somewhat larger quantities of material could be handled at higher temperatures. They also stressed the importance of maintaining the whole apparatus at a constant temperature and of ensuring adequate equilibration within the apparatus before starting the chromatogram. These conditions may be difficult to fulfil using a large conventional tank, and we have described elsewhere[4] a small all-metal apparatus designed to facilitate working at temperatures other than that of the laboratory. Using this apparatus we have been able to compare the R_F values of a number of sugars throughout the temperature range 0–50° C.

This series of experiments showed that R_F values of sugars vary considerably with temperature and it became apparent that, as in the case of the amino-acids reported by Consden, Gordon and Martin, the factor exerting the greatest influence was the water-content of the solvent. In the case of solvents having an increased water content at higher temperatures the R_F values increased over the range 0–50° C. The opposite effect was shown by solvents having a negative temperature coefficient with respect to water content, that is, the R_F values decreased over the range 0–50° C. Since they are so greatly influenced by the temperature of working, it follows that when R_F values are quoted the temperature at which the separations were made should be specified.

Isherwood and Jermyn[5] have related the R_F values of any individual sugar in a series of different solvents to the molar fraction of water present in each solvent. They obtained a straight line on plotting $\log (1/R_F - 1)$ against $-\log N$ (where N is the molar fraction of water in the moving phase). Apart from R_F, N is the only variable in this equation, which should, therefore, be applicable to the changes in R_F produced by using the same solvent at different temperatures, if these variations are dependent on the water content of the solvent. Plotting $\log (1/R_F - 1)$ against $-\log N$ for our data, using values for N calculated from data given in the International Critical Tables, a straight line is obtained. Some examples are shown in Fig. 1. Thus we have been able to confirm the Isherwood and Jermyn relationship and to show that the effects of temperature on the R_F values are the result of the variations in the solubility of water in the moving phase.

Changes in temperature also influence the speed of development of the chromatogram since the

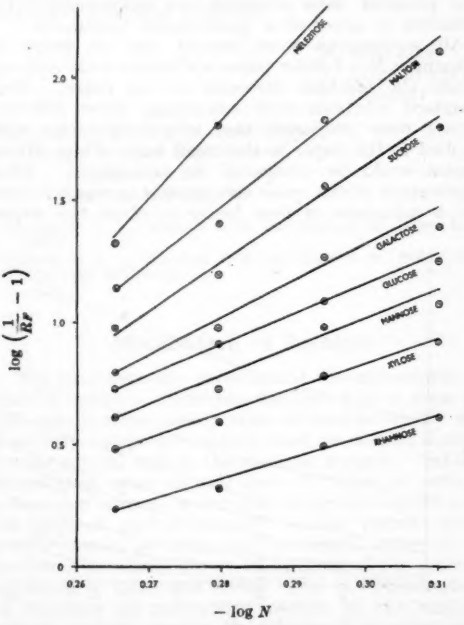


Fig. 1

Table 1

Solvent	Melezitose $R_F \times 100$ 0°	20°	37°	50°
n-Butyl alcohol	0·3	0·5	1·5	4·4
iso-Butyl alcohol	0·4	—	1·2	—
n-Amyl alcohol	—	—	—	0·3
Phenol	23·5	23·8	34·6	39·3
s-Collidine	—	20·2	9·8	5·1

Solvent	Glucose. $R_F \times 100$ 0°	20°	37°	50°
n-Butyl alcohol	4·7	7·5	12·3	15·8
iso-Butyl alcohol	3·8	—	9·5	—
n-Amyl alcohol	—	—	2·9	3·9
Phenol	30·3	32·7	41·0	45·3
s-Collidine	—	38·6	27·7	22·6

Solvent	Rhamnose. $R_F \times 100$ 0°	20°	37°	50°
n-Butyl alcohol	19·1	24·4	31·9	36·9
iso-Butyl alcohol	19·6	—	27·0	—
n-Amyl alcohol	—	—	13·2	17·4
Phenol	54·1	53·9	61·5	62·4
s-Collidine	67·7	64·9	56·4	53·8

physical characteristics—density, viscosity and surface tension—of the solvent are affected and hence the 'diffusion coefficient' of the paper. Müller and Clegg[6] have investigated the rate of the movement of the solvent along the paper. They conclude that the distance moved by the solvent front is in accordance with the equation

$$h^2 = Dt - b$$

where h is distance moved by the solvent front, D is diffusion coefficient, t is time, b is a constant. The diffusion coefficient can be expressed in terms of the physical constants of the solvent by using the relationship

$$D = a\gamma/\eta d + b$$

where γ is surface tension, η is viscosity, d is density and a and b are constants for the paper.

Thus temperature effects on the diffusion coefficient and hence on the distance moved by the solvent front in a given time can be predicted from a knowledge of the temperature coefficient of the ratio $\gamma/\eta d$. The physical data available are unfortunately insufficient to allow of a quantitative treatment.

All separations were carried out on strips of Whatman No. 1 filter paper six inches wide and cut across the machine direction of the paper. Five standard solutions each containing three different sugars were prepared, and aliquot portions were applied to the paper in the usual way. Thus, fifteen sugars could be compared on one paper. After application of the spots the apparatus was set aside for a minimum of four hours to allow the paper, the atmosphere and the solvents to reach a state of equilibrium. In order to reduce the number of variables to a minimum, only two-component solvent systems were investigated. In every case the phases were allowed to equilibrate at the temperature at which the chromatogram was to be made before the organic phase was introduced into the apparatus. Table 1 gives the results at four different temperatures for three typical sugars—melezitose, glucose and rhamnose—with a number of different solvents. Fig. 2 illustrates the relation between R_F values and temperatures for a series of sugars chromatographed with water-saturated butanol. Since solvents having a decreased water content at higher temperatures are much the rarer kind, R_F values for this type can be given only for *s*-collidine. Experiments with triethylamine, however, have shown the same general tendency, although the extreme volatility of this solvent makes it impossible to give accurate results.

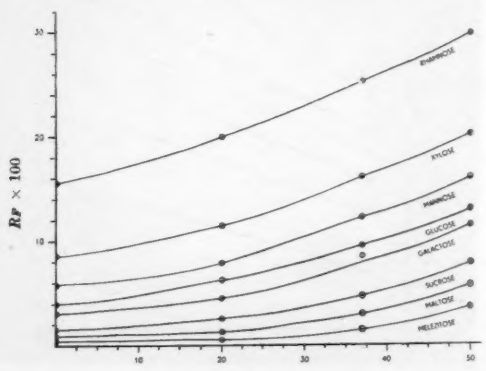


Fig. 2

Margaret Alcock
J. S. Cannell

Thomas Kerfoot and Co., Ltd.,
Vale of Bardsley,
Ashton-under-Lyne,
Lancs.
Sept. 30.

[1] Consden, R., Gordon, A. H., and Martin, A. J. P., *Biochem. J.*, **38**, 224 (1944).
[2] Hough, L., Jones, J. K. N., and Wadman, W. H., *J. Chem. Soc.*, 1702 (1950).
[3] Counsell, J. N., Hough, L., and Wadman, W. H., *Research*, **4**, 143 (1951).
[4] Alcock, M., and Cannell, J. S., *Analyst*, **79**, 389 (1954).
[5] Isherwood, F. A., and Jermyn, M. A., *Biochem. J.*, **48**, 515 (1951).
[6] Müller, R. H., and Clegg, Doris L., *Anal. Chem.*, **23**, 408 (1951).

Bacterial Degradation of Nicotinic Acid

A bacterium utilizing nicotinic acid was isolated from culture media made up of a solution of nicotinic acid and dilute sodium sulphide and inoculated with a small amount of Potomac mud. After allowing the bacteria to grow anaerobically, several successive transfers were made into a medium containing nicotinic acid, peptone, yeast extract, metals, phosphate and sodium sulphide. The mixed bacterial suspension was then serially diluted in agar media of the same composition under anaerobic conditions. This serial dilution was repeated until the bacterium utilizing nicotinic acid was isolated in pure culture. By this enrichment culture technique, an anaerobic spore-forming rod was isolated which ferments nicotinic acid and which utilizes high concentrations of this compound for its growth. Maximum growth is achieved in the presence of 0·6 per cent yeast extract, 0·2 per cent peptone and 0·4 per cent nicotinic acid. No growth occurs with yeast extract and peptone alone. Neither will the bacterium grow on nicotinic acid as a sole source of carbon.

In growing cultures of this organism, it was observed that acetic and propionic acids were formed from nicotinic acid. These acids were determined by paper chromatography[1] and also separated on a silica-gel column[2]. They were present in equal amounts. Further studies with resting cell suspensions demonstrate that nicotinic acid was fermented to ammonia, carbon dioxide, acetic and propionic acids according to the following reaction:

$$4H_2O + C_5H_4N{-}COOH \rightarrow NH_3 + CO_2 + CH_3COOH + CH_3CH_2COOH$$

TABLE 1

Additions: 20 mgm. washed cell suspension, 200 μmoles phosphate buffer *p*H 6·0, nicotinic acid as indicated, water to 2 ml. final volume. Gas, nitrogen. Temperature, 26° C. Reaction started with the tipping of the bacteria and continued to cessation of gas production. Figures corrected for endogenous metabolism

Nicotinic acid added (μmoles)	0·94	1·89	3·76
Carbon dioxide produced (μmoles)	0·82	1·65	3·25

TABLE 2

Additions: 20 mgm. washed cell suspension, 50 μmoles potassium bicarbonate, nicotinic acid as indicated, water to 2 ml. final volume. Gas, 5 per cent carbon dioxide in nitrogen. Temperature, 26° C. Experiment started with the tipping of the bacteria and continued to cessation of gas production. Figures corrected for endogenous metabolism

Nicotinic acid added (μmoles)	0·94	1·89	3·76	5·65	7·5
Acid produced (μmoles carbon dioxide)	0·94	1·88	3·20	4·70	6·15

Table 1 demonstrates that resting cells will catalyse the formation of carbon dioxide from nicotinic acid. In Table 2 it can be seen that for each mole of nicotinic acid in the reaction mixture approximately one mole of acid was produced as measured by the release of carbon dioxide from bicarbonate buffer at *p*H 7·4. Since three acids and one base are produced from one acid by this reaction, only one acid equivalent can be measured by this technique.

In a typical large-scale experiment, 131 μmoles of nicotinic acid were incubated in bicarbonate buffer at *p*H 7·4 with a suspension of resting cells until acid production ceased. All the nicotinic acid, as determined by the cyanogen bromide method[3], had disappeared. As measured by release of carbon dioxide from the bicarbonate buffer, 109 μmoles of acid, corrected for endogenous acid production, were formed. 122 μmoles of ammonia was also formed.

The reaction mixture was then acidified and steam distilled, and 345 μmoles of steam-volatile acids collected. This was shown to be, by paper chromatography, a mixture of acetic and propionic acids. A comparable cell suspension incubated without nicotinic acid produced 128 μmoles of acetic acid and no propionic acid. Thus, correcting for this endogenous production of acetic acid, 217 μmoles of acetic and propionic acids was produced from nicotinic acid. Determination of the Duclaux numbers of this mixture demonstrated that, of the total acid produced from nicotinic acid, 110 μmoles was acetic acid and 107 μmoles was propionic.

The acid mixture was separated on a silica gel column into acetic and propionic acids. These were identified by their positions on silica-gel columns and paper chromatograms, and by Duclaux distillation. Acetic acid was also characterized as the sodium uranyl acetate[4].

I wish to thank Dr. E. R. Stadtman for helpful discussions during the course of this work.

ISAAC HARARY
(American Cancer Society Postdoctoral Fellow)

Laboratory of Cellular Physiology and Metabolism,
National Heart Institute,
National Institutes of Health,
Bethesda, Maryland.
Aug. 31.

[1] Jones, A. R., Dowling, E. J., and Skraba, W. J., *Anal. Chem.*, **25**, 394 (1953).
[2] Elsden, S., *Biochem. J.*, **40**, 252 (1946).
[3] Hughes, D. E., and Williamson, D. H., *Biochem. J.*, **55**, 852 (1953).
[4] Kley, P. D. C., "Organische Mikrochemische Analyse" (Vosa, Leipzig, 1922).

Preparation of Antiglobulin Sera

THE antiglobulin test of Coombs, Mourant and Race is already widely employed in routine practice, and many laboratories are producing for themselves antiglobulin sera. Rabbits were commonly immunized by unchanged human serum or its globulin fraction. The latter method, especially in the smaller laboratories, meets difficulties.

The technique employed by us is very simple. To 1 ml. of packed rabbit red cells are added 10 ml. of pooled human serum heated for 30 min. at 56° C. The tubes are then left in room temperature for 30 min., being shaken several times. The agglutinated cells are washed three times with saline, suspended in 3 ml. of saline and injected into the ear vein. For immunization two injections weekly were carried out for six weeks. For each injection freshly prepared agglutinate was used. The rabbits did not show any abnormal symptoms.

By this method four antiglobulin sera were obtained, and they have been used for the past six months in routine tests of our laboratory. All the antiglobulin sera have sufficiently high titres; human red cells sensitized by incomplete anti-*D* sera were agglutinated by two antiglobulin sera up to the dilution of 1 : 1,280; the titres of the remaining two sera were 1 : 5,120 and 1 : 20,480 respectively. The injections caused no increase in the titre of natural heteroagglutinin against human red cells, and the titre of this antibody remained low, that is, about 1 : 4. Our antiglobulin sera could be therefore employed (without previous absorption) at several dilutions, and errors caused by zonal phenomena could be eliminated.

Antiglobulin sera obtained by our technique contain antibodies against globulin denatured on the surface of red cells as a result of antigen–antibody reaction. In this connexion one would expect greater specificity of the tests performed with our sera than with sera obtained otherwise.

F. MILGROM
T. LUSZCZYNSKI
S. DUBISKI

Institute of Medical Microbiology,
Silesian Medical High School,
Zabrze 8,
Rokitnica, Poland.

[1] Coombs, R. R. A., Mourant, A. E., and Race, R. R., *Lancet*, **ii**, 15 (1945).
[2] Coombs, R. R. A., Mourant, A. E., and Race, R. R., *Brit. J. Exp. Path.*, **26**, 255 (1945).

Metabolism of Sorbitol

WE have recently investigated the metabolism in man of sorbitol uniformly labelled with carbon-14. The results show clearly that sorbitol is rapidly and relatively completely metabolized to carbon dioxide in the normal and in the diabetic subject. Table 1 shows that, after an oral dose of 35 gm. of sorbitol containing carbon-14 sorbitol (total activity 30 μc.), the expired carbon dioxide became highly radioactive within an hour and remained active for a further 8 hr. Only about 10 per cent of the activity appeared in urine and faeces. The exact percentage of recovery of radioactive carbon in the expired carbon dioxide cannot be calculated in these two cases without certain assumptions regarding the total

Table 1. Activity of Expired Carbon Dioxide after the Ingestion of 35 gm. of Sorbitol uniformly labelled with Carbon-14 (total activity 30 μc.)

Normal subject		Diabetic subject	
Time after ingestion of sorbitol (hr.)	Counts/min./gm. carbon dioxide	Time after ingestion of sorbitol (hr.)	Counts/min./gm. carbon dioxide
1	411	½	54
3	820	1	134
4	838	3	519
6	475	4½	750
8	260	5½	670
24	0	7½	456
		10½	260
		24	0

carbon dioxide production, which for experimental reasons could not be measured in these tests. Nevertheless, at least 70 per cent and probably 90 per cent of the activity administered can be acounted for in the expired carbon dioxide.

Our investigations so far throw no light on the pathway of metabolism of sorbitol, but show clearly that this polyhydric alcohol must provide calories. Its precise mechanism of metabolism in both the normal and diabetic subject requires further investigation.

We wish to thank Messrs. Howards of Ilford, Ltd., for financial support of this investigation.

L. H. Adcock
C. H. Gray

Department of Chemical Pathology,
King's College Hospital Medical School,
London, S.E.5.

Nov. 25.

Antenatal Sex Determination

For thousands of years people have had a desire to know the sex of an expected child. Many methods have been tried for antenatal sex determination; but even modern ones, based upon scientific hypotheses, have failed to receive sufficient confirmation for general acceptance.

Since Barr *et al.*[1], in 1949 in *Nature*, described morphological sex differences of the nerve cell nuclei of cats, their observations have been repeated on several human and animal cell types. The observation that the cell nuclei of the amniotic membrane in cats[2] and of the oral epithelium of newborn infants[3,4] exhibit easily demonstrable sex differences led to an investigation whether human amniotic fluid contains enough well-preserved desquamated cells to make possible the determination of the fœtal sex.

Amniotic fluid was collected from pregnant women at term by rupture of the membranes for induction of labour. In a few cases the fluid was obtained in the middle of pregnancy from cases for surgical interruption, by puncture of the membranes through the uterine wall either vaginally or through a laparotomy. Care was taken to avoid admixture of maternal cells. The specimens were centrifuged and the vernix and supernatant fluid removed. The cells were smeared on microscopical slides coated with egg-albumin or human serum and fixed in Papanicolaou's fixative. The staining procedure was carried out with cresyl violet as described by Moore and Barr[4].

The smears were examined by one of us without knowledge of the fœtal sex even in those cases where delivery had taken place before the examination could be carried out. One of our first specimens was misinterpreted owing to lack of experience, but after that our results have been correct in all of twenty cases. Numerous well-preserved cells are found at term, and enough in the middle of pregnancy to allow a definite distinction between male and female cells by the absence or presence of the typical sex chromatin mass in the cell nuclei. Many of the cells have a close resemblance to those of oral smears and might conceivably be epithelial cells from the fœtal alimentary or genito-urinary tracts.

The crucial point of the method is the avoidance of admixture of maternal cells. If the puncture is made through the uterine wall, a needle with a stylet should be used; and if the amniotic fluid is collected by rupture of the membranes from below, a catheter should be inserted into the bag of water. The specimens should be fixed as soon after collection as possible to avoid autolysis.

Although transabdominal puncture of the uterus has been carried out often for therapeutic and experimental reasons without accidents, mere curiosity does not justify the procedure, and its practical value is probably limited in the human. If the results are confirmed in animals, however, it might become of great significance in veterinary practice.

Fritz Fuchs
Department A,
Royal Maternity Hospital,
Rigshospitalet,
Copenhagen.

Povl Riis
Department F,
Copenhagen County
Hospital,
Hellerup.

Nov. 23.

[1] Barr, M. L., and Bertram, E. G., *Nature*, **163**, 676 (1949).
[2] Graham, M. A., *Nature*, **173**, 310 (1954).
[3] Marberger, E., Boccabella, R. A., and Nelson, W. O., *Proc. Soc. Exp. Biol. Med.*, **89**, 488 (1955).
[4] Moore, K. L., and Barr, M. L., *Lancet*, II, 57 (1955).

Effect of ββ-Methylethyl Glutarimide and Amytal on Rat-liver Mitochondrial Respiration

In 1954, Shaw *et al.*[1] showed that ββ-methylethyl glutarimide was capable of reducing the narcotic effect of barbiturates in animals and man, and suggested that in therapeutic dosage it exerts a direct antagonism to barbiturates.

It has been known for a long time that barbiturates depress the respiratory system of the cells, and preliminary experiments[2] seem to show that a certain correlation exists between the narcotic effect of barbiturates and their ability to depress the respiration in an isolated liver mitochondrial system. This prompted me to see if ββ-methylethyl glutarimide exerted an antagonistic effect on barbiturates in this system.

Mitochondria were prepared from rat-liver homogenates made in 0·25 *M* sucrose[3] containing 0·01 *M* ethylenediaminetetraacetic acid (versene)[4], and incubated in the presence of glutamate, orthophosphate, adenylic acid, glucose and yeast hexokinase. The amytal (5-ethyl-5-*iso*amylbarbituric acid) used was an ordinary commercial product. The ββ-methylethyl glutarimide was a sterile solution containing 50 mgm. in 10 ml. of normal saline ('Migimide' from Nicholas Products Laboratories, Ltd., Slough).

It appears from Table 1 that the oxygen consumption of the mitochondria decreased with increasing amytal concentrations. Addition of ββ-methylethyl glutarimide, 0·8 and 1·6 µmoles/ml., had no effect on the oxygen consumption, whereas ββ-methylethyl glutarimide in concentrations of 3·2

Table 1. Effect of ββ-Methylethyl Glutarimide and Amytal on Respiration of Rat-liver Mitochondria

Additions	Respiration (μ atoms oxygen)					
	Experiment 1			Experiment 2		
Amytal	Without ββ-methylethyl glutarimide	With ββ-methylethyl glutarimide 0·8 m*M*	With ββ-methylethyl glutarimide 1·6 m*M*	Without ββ-methylethyl glutarimide	With ββ-methylethyl glutarimide 3·2 m*M*	With ββ-methylethyl glutarimide 10·3 m*M*
0	23·0	—	24·7	17·3	15·7	7·1
0·45 m*M*	16·0	15·7	16·1	—	—	—
0·9 m*M*	7·7	8·0	7·7	14·4	10·7	4·9

Each Warburg vessel contained: mitochondria, 1/12 rat liver; glycylglycine, 200 μ*M*; potassium chloride, 150 μ*M*; glucose, 200 μ*M*; *dl*-glutamate, 60 μ*M*; orthophosphate, 100 μ*M*; adenylic acid, 6 μ*M*; magnesium ions, 6 μ*M*; yeast hexokinase ('step-5' purity according to Berger *et al.* (ref. 5), preparation from 11 kgm. yeast dissolved in 30 ml. of 1 per cent glucose), 0·1 ml. Final volume 2·2 ml., pH 7·6. Temperature 30° C.: gas phase, air. Time of incubation, 30 min.

μmoles/ml. or more depressed the oxygen consumption. If ββ-methylethyl glutarimide was added to mitochondria, the oxygen consumption of which had beforehand been inhibited by amytal, low concentrations did not exert any effect, whereas higher concentrations which *per se* inhibit the oxygen consumption of the mitochondria intensified the depressing action of amytal.

Thus, the investigation did not disclose any antagonistic effect of ββ-methylethyl glutarimide on amytal in this system. On the contrary, in higher concentrations it intensified the depressing action of amytal on the mitochondrial respiration.

O. Jalling

Department of Physiology,
University of Aarhus,
Denmark.
Oct. 6.

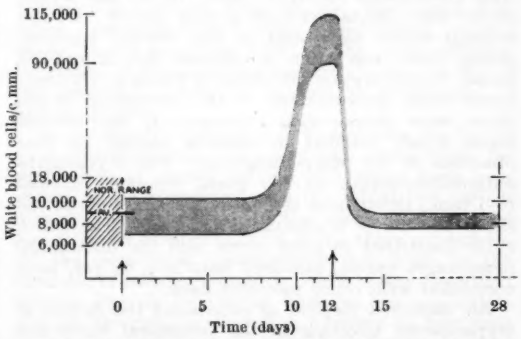
[1] Shaw, F. H., Simon, S. E., Cass, N., Shulman, A., Anstee, J. R., and Nelson, E. R., *Nature*, **174**, 402 (1954).
[2] Jalling, O., Lindberg, O., and Ernster, L., *Acta Chem. Scandinav.*, **9**, 198 (1955).
[3] Schneider, W. C., and Hogeboom, G. H., *J. Biol. Chem.*, **183**, 123 (1950).
[4] Slater, E. C., and Cleland, K. W., *Nature*, **170**, 118 (1952).
[5] Berger, L., Slein, M., Colowick, S. P., and Cori, C. F., *J. Gen. Physiol.*, **29**, 379 (1946).

Remission of Rat Lymphocytic Leukæmia 8 following Intravenous Administration of 4-(*p*-Diethylaminostyryl)quinoline Dihydrochloride

Earlier studies[1] indicated that oral administration of certain styryl quinolines resulted in complete absorption of lymphoma 8 growing in inbred rats of the strain of its spontaneous origin. The neoplastic cells of this lymphoma appear in the bloodstream of the host animal as early as 18 hr. after subcutaneous implantation[2] and increase greatly, in some instances, to as many as 100,000 per c.mm. in the eighteen to twenty-one days before death of the rat. Intraperitoneal injection of 1 ml. of this lymphogenous blood into normal rats of the same strain produces a lymphocytic blood picture which bears a resemblance to certain types of clinical lymphocytic leukæmia. This lymphocytic leukæmia (rat lymphocytic leukæmia 8) is always fatal within twelve to twenty days. In view of their anti-lymphoma action, it seemed of interest to determine whether styryl quinolines, intravenously administered, would have any effect on this type of leukæmia in rats.

The two compounds, 4-(*p*-dimethylaminostyryl)-quinoline and 4-(*p*-diethylaminostyryl)quinoline, which possessed the greatest anti-lymphoma properties, are not soluble in water and only slightly soluble in propylene glycol. Among the compounds which we synthesized, two (the mono- and the di-hydrochloride of 4-(*p*-diethylaminostyryl)quinoline) were soluble in aqueous solution. The dihydrochloride, being the more soluble, was selected for this study.

The sixteen rats in our experimental series varied in weight from 150 to 200 gm. Each rat was injected intraperitoneally with 1 ml. of lymphogenous blood (from the heart) of a rat in which lymphoma 8 had been implanted subcutaneously fourteen to eighteen days previously. The number of white cells present in blood of normal rats is more variable than that of humans. Counts range from 6,000 to 18,000, with an average of 9,000 per c.mm.; the majority (60–70 per cent) of the white blood cells are lymphocytes rather than polymorphonuclear neutrophils. As shown in Fig. 1, the white cells in the blood increased slowly during the first five to seven days after transmission of the disease; the number then rose rapidly, reaching as high as 115,000 per c.mm. twelve days after the intraperitoneal injection. Stained preparations (Wright's stain) of the blood of untreated rats showed numerous large lymphoblast-like cells, some in mitotic division. On the twelfth day all the rats were extremely ill. On this day, twelve of the rats were each given a single intravenous injection of 4 mgm. of 4-(*p*-diethylaminostyryl)quinoline dihydrochloride dissolved in ½ ml. of sterile distilled water. The remaining four rats were not treated. On the following day the four untreated and one treated rat were dead. On the second day after treatment, the surviving eleven rats had recovered their vigour, and the white blood cells had dropped to 8,500–10,000 per c.mm. (Fig. 1). On the third day after treatment, the white blood cells were 7,500–9,500 per c.mm. The rats gained weight and the white blood cells remained at this level during the following fourteen days (Fig. 1). In stained blood smears during this



Arrow at 0 days marks an intraperitoneal injection of 1 ml. of blood from rat lymphoma 8; arrow at 12 days marks an intravenous injection of 4 mgm. of 4-(*p*-dimethylaminostyryl)quinoline dihydrochloride

Fig. 1. Total white blood-cell counts in rat lymphocytic leukæmia 8 before and after intravenous administration of 4-(*p*-diethylaminostyryl)quinoline dihydrochloride. Normal range, hatched; average, stippled

period, only normal white cells could be found. The large lymphoblasts present in the blood before treatment seemed to have disappeared entirely.

These results seem to indicate that the intravenous administration of 4 mgm. of 4-(*p*-diethylaminostyryl)-quinoline dihydrochloride was followed by a remission of the leukæmic blood picture in rat lymphocytic leukæmia 8, but not by a depression of the total white count below the normal level in a fourteen-day observation period.

This investigation was supported in part by grants from the Pew Memorial Foundation and the Medical Research Foundation and in part by grant *C*-285(*C*7) from the National Cancer Institute, Department of Health, Education and Welfare.

Boland Hughes
Margaret Reed Lewis
Aubrey L. Bates

Department of Urologic Surgery,
Hospital of the University of Pennsylvania,
Wistar Institute of Anatomy and Biology,
Philadelphia.

Nov. 30.

[1] Hughes, B., Bates, A. L., Bahner, C. T., and Lewis, M. R., *Proc. Soc. Exp. Biol. Med.*, **88** (2), 230 (1955). Lewis, M. R., Hughes, B., Bahner, C. T., and Bates, A. L., *Growth*, **19**, 1 (1955). Lewis, M. R., Hughes, B., and Bates, A. L., *Growth* (in the press).
[2] Lewis, M. R., *Science*, **118**, 355 (1953); *Growth*, **18**, 97 (1954).

Responses of Domestic Animals to Infections of *Trypanosoma vivax*, *T. congolense* and *T. brucei*

In an extensive investigation, involving more than a hundred domestic animals in the Gold Coast (goats, sheep and horses), on the hæmatological and biochemical changes produced by trypanosomiasis infections, forty animals have died with noteworthy findings.

The types of response could be arranged in four categories: acute, sub-acute, chronic and cryptic. In most cases, the animals developed a severe anæmia which in the acute response proved rapidly fatal (about six weeks). An attempt at recovery of erythrocyte values was made in the sub-acute response, followed by a fall which terminated in death in about three months from inoculation. Chronic responses showed an initial fall in red cells with subsequent recovery, often to normal levels, which was maintained over a long period. Of the animals which have died in the chronic response group, there was often a terminal fall in red-cell count. In the cryptic infections in which no trypanosomes were demonstrable in the peripheral blood, there were characteristic changes in the red-cell count which resulted in anæmia similar to that observed in the other categories. The erythrocyte sedimentation-rate in the goats remained normal (0–1 mm.) throughout the entire period, while in the sheep and horses it gradually increased. The leucocytes fluctuated in total count and the differential percentages varied, but they have not, as yet, been correlated with other recorded data.

An improved method of estimating the degree of trypanosome infection in the peripheral blood has been devised. Wide variation occurred from day to day in the number of trypanosomes in the *T. vivax* and *T. congolense* infections, with long periods when none could be found in the peripheral blood. In the case of *T. brucei*, trypanosomes were only seen on one or two occasions even though the infection extended over several months. This is of interest in view of the low incidence of *T. brucei* hitherto recorded in game and domestic animals of the Gold Coast. No trypanosomes occurred in the peripheral blood in cryptic infections.

Blood sugar, bilirubin and specific gravity remained unchanged in most of the animals. In the final stages of the disease, the animals were often emaciated and showed a severe reduction in weight. Temperature readings revealed no significant variations.

Histopathological material was collected from all the dead animals, some of which showed interesting pathological changes in the lung tissue with extensive congestion of the alveoli.

A detailed account of this investigation will be published elsewhere, as well as a report of the histopathology.

E. E. Edwards
University College of the Gold Coast,
Achimota.

J. M. Judd
(Laboratory Superintendent)
F. A. Squire
(Director)

Department of Tsetse Control,
Achimota Research Station,
Gold Coast.

Dec. 1.

5-Hydroxytryptamine in Serum

The pharmacologically active substance 5-hydroxytryptamine is known to be liberated from platelets during clotting. The amount estimated in serum has, however, been found to depend on the way the serum is prepared, and the purpose of this communication is to direct attention to this phenomenon, which may cause discrepancies between the results of different workers.

Human blood was withdrawn from an arm vein into a glass syringe which had been treated with a liquid silicone (D.C. 550). The first 2 ml. of blood was taken in a separate syringe and discarded to avoid contamination with tissue thromboplastin.

The blood was allowed to clot at 37° C. in the following ways: (1) The blood was placed in a glass test-tube and allowed to stand without agitation for 30 min.; (2) the blood was placed in a glass test-tube containing a glass marble; the tube was stoppered and placed in a machine which tipped the tube through ± 20° from horizontal at a rate of 15 cycles per min., for 30 min.

In each case the clotted blood was centrifuged at 3,000 rev./min. for 30 min., by which time the serum was free of platelets. The serum was transferred to a small glass bottle and stored at − 17° C. until extracted.

Acetone extracts of the serum were assayed on the rat uterus, as recommended by Amin, Crawford and Gaddum[1]. An attempt to simplify this procedure by testing the serum directly on the uterus was unsuccessful owing to the presence in the serum of a substance causing a slow contraction of the uterus and not antagonized by lysergic acid diethylamide. The effects of the acetone extracts were invariably abolished by this drug, as were those of 5-hydroxytryptamine itself. Zucker and Borrelli[2] tested serum directly on the rat colon and do not seem to have met complications.

Table 1. 5-HYDROXYTRYPTAMINE EQUIVALENT OF SERUM (μGM./L.)

Stationary	160	154
Tipped	116	75

The results in Table 1 indicate that agitation during clotting results in a decreased amount of 5-hydroxytryptamine in the serum.

In another experiment a large amount of serum was prepared without agitation. Part of this serum was then tipped, part was allowed to stand, and part was tipped with added clot, all at 37° C. for 30 min. There was no significant difference between the 5-hydroxytryptamine equivalents of these three fractions, and none could be extracted from the clot. This result suggests that the clot does not adsorb 5-hydroxytryptamine and that mechanical disturbance after clotting even in the presence of the clot does not destroy it.

If serum is tipped during clotting, as recommended by Biggs and Douglas[3] for thromboplastin generation tests, its 5-hydroxytryptamine equivalent is likely to be lower than that of serum prepared without tipping.

Thanks are due to Dr. G. D. Forwell for assistance in preparation of serum samples.

D. F. SHARMAN
FRANK M. SULLIVAN

Department of Pharmacology,
University, Edinburgh.
Oct. 28.

[1] Amin, A. H., Crawford, T. B. B., and Gaddum, J. H., *J. Physiol.*, **126**, 596 (1954).
[2] Zucker, M. B., and Borrelli, J., *J. App. Physiol.*, **7**, 425 (1955).
[3] Biggs, R., and Douglas, A. S., *J. Clin. Path.*, **6**, 23 (1953).

Phosphorylation as a Possible Factor in the Pasteur Effect in Plants

AFTER the discovery of the participation of phosphate in glycolysis, suggestions that the Pasteur effect might be explicable in terms of the different rates of aerobic and anaerobic phosphorylation were made by Lennerstrand[1], Turner[2] and especially by Johnson[3]. In modern terms, the conservation of carbon by oxygen, which has been defined as the Pasteur effect, could be due to oxidative phosphorylation lowering the concentration of inorganic phosphate, or the ratio of adenosine di- to adenosine tri-phosphate, to levels which would limit the rate of glycolysis. The development of methods for measuring the concentration of these substances enables investigation of this hypothesis. The work to date has been restricted to measurements in the developing pea seed, in which the concentration of the phosphate esters is relatively high, and for which satisfactory analytical methods have been developed.

A typical experiment utilized six comparable samples of pea seeds taken from two pods past commercial maturity, each sample comprising two seeds, one from each pod. The testas were removed from all seeds (because they were shown to restrict gaseous diffusion), and the peas were placed overnight in water-saturated air. The experimental procedure is outlined, together with a typical respiration-rate curve, in Fig. 1. For each analysis the vessel was removed from the manometer, quickly stoppered, taken to a cold room and the seeds extracted by grinding with a small glass pestle and mortar with

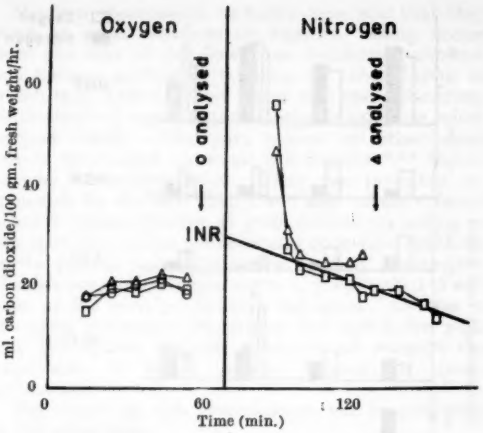


Fig. 1. Rate curves of respiration and fermentation of mature peas, showing the sampling periods for estimate of phosphate fractions. Dickens–Simer apparatus; 25° C. Each experiment utilized twelve seeds, each sample of two seeds. At the arrows, sample(s) were removed for the determination of phosphate fractions

3 ml. 5 per cent perchloric acid. The extract was centrifuged, the supernatant solution neutralized with potassium hydroxide and held overnight at − 15° C. Next day the material was thawed and the precipitate (potassium perchlorate) removed by centrifugation. The concentrations of adenosine tri- and di-phosphate, hexose monophosphate (the sum of glucose 1-phosphate, glucose 6-phosphate and fructose 6-phosphate) and hexose diphosphate (fructose 1 : 6-diphosphate) in each extract were measured by the method of Slater[4], the concentration of inorganic phosphate by the method of Allen[5] or of Weil-Malherbe and Green[6]. The respiration of each sample of two peas was measured in oxygen at 25° by the manometric method of Dickens and Simer[7]. After the tipping of the acid and the measurement of the carbon dioxide output, the vessel was flushed with pure nitrogen gas, and the succeeding pressure differences recorded gave a measure of the rate of fermentation, as shown in Fig. 1. The mean R.Q. of the seed without testa was 0·87 ± 0·01 (13 observations); that of the seed with testa in oxygen, or without testa in air, was about 1·1, which suggests that some fermentation occurs under these conditions due to the high diffusion resistance of the seed coat and cotyledon. In Fig. 1 the respiration-rates are plotted as production of carbon dioxide.

It is difficult to know how to estimate the initial rate of fermentation. The very high initial values for production of carbon dioxide in nitrogen have been shown to be correlated with the initial low carbon dioxide partial pressure in the vessel, and may be due to rapid decarboxylation under these conditions. As the respiration measurements are made in the presence of baryta, it may be better to use these high figures. For the time being, however, we have extrapolated the rates measured in nitrogen to zero time in nitrogen, neglecting the initial high figures obtained within 30 min. after transfer to nitrogen (Fig. 1). These extrapolations will give minimum figures for initial rate of fermentation and, therefore, for the Pasteur effect. The value of the ratio of initial rate of fermentation to carbon dioxide production varied

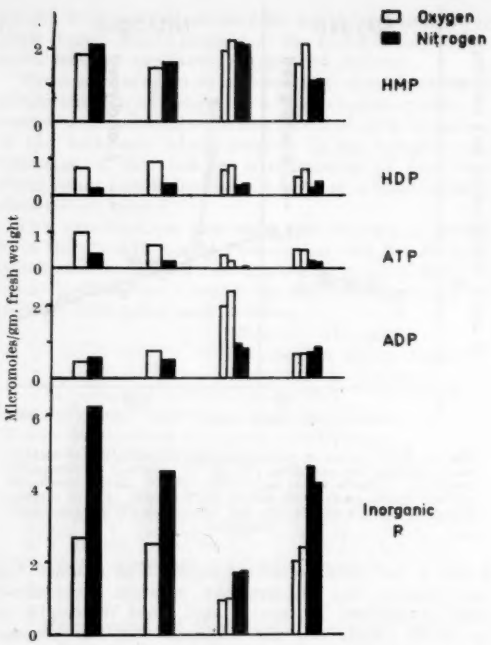


Fig. 2. Results of experiments of the type illustrated in Fig. 1, showing the change in phosphate fractions on transference from oxygen to nitrogen

when so measured from 1 to 1·6. H. G. Wager (private communication) has found that in the first three hours after transfer of pea seed to nitrogen, ethanol, equivalent to about 40 per cent of the carbon dioxide, was produced and, in addition, some acetaldehyde and lactic acid were formed in mature peas. It seems reasonable, therefore, to assume that the high values for this ratio indicate the existence of a Pasteur effect; its extent in these preliminary experiments cannot be measured.

Table 1

Experiment	Adenosine diphosphate / Adenosine triphosphate	
	Oxygen	Nitrogen
1	0·4	1·4
2	1·2	2·3
3	7·6*	18·2*
4	1·3*	4·0*

* Mean of two extractions.

Fig. 2 and Table 1 show the analytical results of all experiments in which tissue was transferred from aerobic to anaerobic conditions. The concentrations of adenosine triphosphate and hexose diphosphate fell consistently in all experiments; inorganic phosphate and the ratio of adenosine di- to tri-phosphate increased. These changes occurred within 1 hr. (in one experiment within 30 min.) of the transfer to nitrogen gas, and their rapidity is of interest when it is remembered that the hypothesis of oxidative anabolism (resynthesis of glycolytic product[8]) is only valid if the transfer to anaerobiosis involves no rapid change in the rate of glycolysis.

These changes of concentration might stimulate the following reactions in glycolysis and starch breakdown:

$$\text{Starch} + P_i \rightleftharpoons \text{glucose 1-phosphate}$$

$$\text{Glyceraldehyde 3-phosphate} + DPN_{ox.} + P_i + ADP \rightleftharpoons \text{glycerate 3-phosphate} + ATP + DPN_{red.}$$

$$\textit{Enol}\text{pyruvate 2-phosphate} + ADP \rightleftharpoons ATP + \text{pyruvate}$$

The results reported are consistent with the hypothesis that on transfer from oxygen to nitrogen there is a rapid increase in concentration of inorganic phosphate and of the ratio of adenosine di- to tri-phosphate. This could give rise to an increased glycolysis, and so explain the Pasteur effect. Further work is envisaged on plants in which this effect is lacking.

K. S. Rowan

Food Preservation Division,
Commonwealth Scientific and
Industrial Research Organization
(stationed in Botany School,
University of Melbourne).

D. E. Seaman
(U.S. Fulbright Research Student)
J. S. Turner

Botany School,
University of Melbourne.

[1] Lennerstrand, A., *Biochem. Z.*, **289**, 104 (1936); *Naturwiss.*, **25**, 347 (1937).
[2] Turner, J. S., *New Phytol.*, **36**, 142 (1937).
[3] Johnson, M. J., *Science*, **94**, 200 (1941).
[4] Slater, E. C., *Biochem. J.*, **53**, 157 (1953).
[5] Allen, R. J. L., *Biochem. J.*, **34**, 858 (1940).
[6] Weil-Malherbe, H., and Green, R. H., *Biochem. J.*, **48**, 286 (1951).
[7] Dickens, F., and Simer, F., *Biochem. J.*, **24**, 905 (1930).
[8] Blackman, F. F., *Proc. Roy. Soc.*, B, **103**, 491 (1928).

Tripping, Crossing and Selfing in Lucerne Strains

There is some controversy on the proportion of lucerne flowers which set seed without tripping; but all investigators have agreed that tripping is essential for high yield of seed. Insect-tripped florets bring about cross-pollination and normally cross-fertilization, while seed setting without tripping or due to automatic tripping results usually in self-pollination and self-fertilization. The population of wild bees, although playing a most effective part in tripping and crossing, is inadequate. The importance of honey bees in tripping has been one of the most controversial subjects; but a number of investigators[1-3] showed that pollen-gathering bees caused a high percentage of tripping and nectar-gathering bees caused only accidental tripping.

There is no evidence as to whether the different strains vary in the amount of florets tripped, either self- or cross-fertilized, or in the number of pods and seeds set under comparable conditions. These aspects and the influence of weather and insects on them have been studied at the National Institute of Agricultural Botany (1953–55) in a number of strains planted as single-spaced plants in the field. Pilot investigations in 1953 showed that early strains (Eynsford, Du Puits, Chartrainvilliers and *W*.268) had a higher number of florets per raceme and, under natural conditions, a higher percentage of florets tripped and pods formed than in mid-season strains (Provence and New Zealand Strain *B*) and in late strains (Grimm and Rhizoma). The early strains also had a higher percentage of self-fertilized florets than mid-season or late strains under cover (my classification[4]). As the number of tripped florets was recorded and calyces marked each day, it was possible to correlate the

Table 1

Strain and treatment	Total florets	Tripped florets (%)	Pods formed			No. of seeds per pod
			Total	% of tripped florets	% of total florets	
Early						
Eynsford						
A	916	81	433	57	47	3·9
B	950	100	362	38	38	2·0
C	995	100	872	87	87	6·9
D	956	—	67	—	7	1·5
Du Puits						
A	928	78	414	56	44	4·0
B	962	100	386	40	40	1·9
C	935	100	758	81	81	7·0
D	945	—	66	—	7	1·5
Mid-Season						
Provence						
A	703	54	131	34	18	3·7
B	781	100	253	32	32	1·7
C	820	100	684	83	83	6·9
D	753	—	28	—	3·7	1·4
Late						
Grimm						
A	719	53	146	38	20	3·8
B	700	100	254	36	36	1·9
C	788	100	668	85	85	6·8
D	763	—	37	—	4·8	1·5

40 racemes were used in each treatment.
(*A*) Under natural conditions—open to all pollinators. (*B*) Artificial tripping and selfing. (*C*) Artificial tripping and crossing. (*D*) Under cover, selfing—no insects.

results with daily weather records. Correlations derived from the means for each strain for ten to fourteen days were highly significant.

More detailed investigations were carried out during 1954–55 with Eynsford, Du Puits, Provence and Grimm strains. Some results for 1955 showing the main differences between strains are given in Table 1.

The number of florets tripped and pods and seeds set under natural conditions in (*A*) treatment was similar for Eynsford and Du Puits. Also, the difference between Provence and Grimm was small; but the difference between them and the early strains was highly significant. Eynsford and Du Puits had the highest number of florets per raceme, percentage of tripped florets and number of pods formed. They also had a higher percentage of self-fertilized florets under cover (*D*) than Provence or Grimm, but this difference was small in treatment *B*. The difference in percentage of pods and seed per pod set under artificial tripping and crossing (*C*) between strains is negligible, but it is considerable between early strains and Provence or Grimm in the actual number of pods and consequently total number of seeds set. In Provence and Grimm the percentage of tripped florets under natural conditions (*A*), artificially selfed florets and pods formed in (*B*) and artificially crossed florets and pods set in (*C*) are in agreement with the figures obtained by Pharis and Urau[4] for similar treatments on an unspecified strain. When the number of seeds set per pod in treatment (*A*) is compared with that obtained in either treatment (*B*) or (*D*), a 2 to 1 ratio is obtained. This is similar to the ratio stated by other investigators[5,6] under similar conditions. However, none of these investigators used early strains or indeed specified the strains used in their experiments; whereas the present investigation shows that the greatest difference is between early strains and mid-season or late strains. I observed when doing artificial tripping and crossing that the early strains tripped more easily than mid-season or late strains. The ease with which they tripped is possibly the most important factor governing the greater number of pods set, as the other pollinating agencies, for example, honey bees, sun and wind, could trip a higher proportion of florets.

My own observation on honey bees was that they work in great numbers on lucerne, taking nectar from the side of the flower, as Reinhardt[2] showed, but causing accidental tripping on other florets on which they landed. They might also cause the cross-pollination of some automatically tripped or wind-tripped florets. The part played by other small insects mentioned by some investigators[3,6,7] should not be under-estimated. They are probably responsible for the fact that I and also others[5,7] found a much higher number of pods formed on selfing in the open than under continuously covered conditions. In the present investigation the range of the number of seeds per pod set under cover (*D*) was only 1–3 and none of the pods produced a full spiral, whereas in the open (treatment *B*), it was 1–5 and a few pods had 2–3 spirals formed. This would support the hypothesis of small insects helping in cross-pollination.

The report on this investigation will be published in full elsewhere.

A. Zaleski
National Institute of Agricultural Botany,
Cambridge.
Oct. 28.

[1] Akerberg, E., and Lesins, K., *Herb. Abstr.*, **18**, 248 (1948).
[2] Reinhardt, J. F., *Herb. Abstr.*, **23**, 91 (1953).
[3] White, W. J., "Advances in Agronomy", **1**, 205 (1949).
[4] Zaleski, A., *J. Agric. Sci.*, **44**, 199 (1954).
[5] Pharis, R. L., and Urau, J., *Can. J. Agric. Sci.*, **33**, 74 (1953).
[6] Knowles, R. P., *Sci. Agric.*, **24**, 29 (1943).
[7] Lesins, K., *Ann. Roy. Agric. Coll., Sweden*, **17**, 442 (1950).

Fixity in Chromosome Number of Plants

Studies on the chromosome behaviour of a large number of vegetatively propagating plants have revealed certain interesting facts. The investigations have mainly centred around members of the Aroideae, Liliaceae, Amaryllidaceae and Dioscoreaceae, including the ornamental ones, especially those with obligate vegetative multiplication[1].

In more than a hundred species of plants so far investigated, no constancy in the chromosome numbers of the somatic cells, even of the same root-tip, was found, and similar results are being accumulated from different groups of plants under investigation. In addition to the normal somatic chromosome number, which occurs with high frequency in the nuclei, irregular numbers of chromosomes are present in numerous cells. No regularity in the sequence of their occurrence was noted and the numbers so far recorded suggest random behaviour. This interesting phenomenon was first noticed in *Caladium bicolor*[1], and on careful scrutiny, the presence of irregular chromosome numbers is gradually being revealed in other species, of which species of *Hemerocallis*, *Haemanthus* and *Crinum* may be cited. In *Hemerocallis citrina* the normal somatic number is 22, whereas complements with 11, 18 and 20 chromosomes also occur frequently in the cells of the same root-tip. Similarly, in *Haemanthus kalbreyeri*, with $2n = 18$ chromosomes, and *Crinum kunthianum*, with $2n = 22$ chromosomes, abnormal numbers, such as 15, $16+f$, 17, $17+f$, $18+2f$, 20, $20+f$, 21 and 10, 12, 13, 14, 15, 17, 18, 20, 23, 24, 25 chromosomes respectively, have been recorded in different cells. The irregularities in these plants not only involve a numerical change but structural alterations are also recorded in cells otherwise showing a normal number of chromosomes. In species of *Hemerocallis*, etc.,

different individuals of the same species differ in the karyotypes of the normal cells, even if these do not differ in chromosome number. In these groups of plants, where sexual reproduction is ineffective, such variations may lead to speciation through their presence on the growing tips of daughter offshoots[2]. Experimental attempts to secure direct evidence of their role in speciation are yielding promising results.

This peculiarity in chromosome behaviour strongly emphasizes the necessity of an extremely cautious approach when investigating the number and behaviour of chromosomes in plants multiplying by vegetative means. The discrepancies often noted in the reports of chromosome numbers of the same species by different authors are significant in this connexion. It is apparent that the idea of the constancy of the chromosome number in cells is not strictly applicable to all plants.

Arun Kumar Sharma
Archana Sharma (*née* Mookerjea)

Cytogenetics Laboratory,
Botany Department,
University, Calcutta 19.
Nov. 15.

[1] Sharma, A. K., and Das, N. K., *Agric. Lusit.*, **16**, 23 (1954). Sharma, A. K., and Bhattacharyya, N. K., Proc. Abst. 41st Ind. Sci. Congr., 147 (1954). Sharma, A. K., and Bal, A. K., *ibid.*, 148 (1954). Sharma, A. K., and De, D., *ibid.*, 248 (1955). Sharma, A. K., *Genetica*, **27**, 323 (1955). Mookerjea, Archana, *Caryologia*, **7**, 1 and 221 (1955).
[2] Sharma, A. K., *Caryologia* (in the press).

Some Problems associated with determining Iron in Plants

It is well known that the total iron content of leaves determined by chemical methods seldom reflects the true iron status of plants. In instances of lime-induced chlorosis in fruit trees[1] or metal-induced iron-deficiency in crop plants[2], the iron content of chlorotic leaves is often reported to be similar or even higher than that of green leaves.

Various workers have shown that the iron determined by leaf analysis is considerably less after washing the leaves either in water containing a detergent or in dilute hydrochloric acid[3]. This difference has been assumed to result from the removal of iron contamination on leaf surfaces, although it has not hitherto been determined whether or not iron is leached from the tissues during leaf washing.

We have found that iron is a serious contaminant on the leaves of tomato grown in a glasshouse, and that it may be removed readily by washing the plant in water containing 0·3 per cent detergent.

The effect of duration of leaf washing on the iron content of tomato 'tops' was investigated as follows: The tomato plants, nine weeks from seed, were cut at approximately 6 in. above soil-level and immersed and well agitated in 0·3 per cent 'Teepol' in distilled water, drained for 5 sec. and then rinsed in distilled water. The results are shown in Fig. 1; half of each time interval was used for the detergent wash and the remainder for water rinsing. Significant amounts of iron were removed during the first 20-sec. washing period, but additional treatment did not further reduce iron. The manganese content of the plants, which is similar to their iron status, was unchanged by the washing treatment. Potassium, which is more

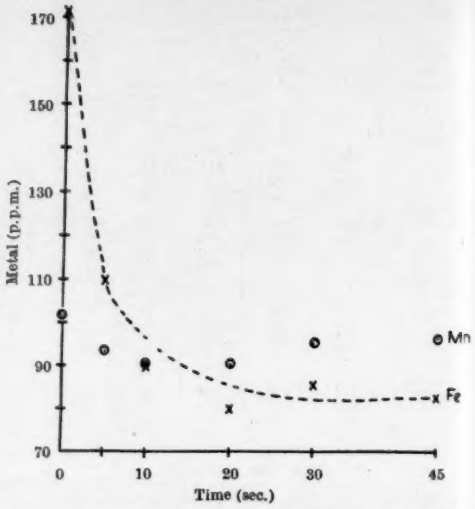


Fig. 1. Iron and manganese contents of tomato leaves after washing them for various periods in 0·3 per cent detergent and distilled water

readily leached than other nutrients, was also unaffected by this treatment. That the iron is removed from the external surfaces only is shown by the fact that the iron content of leaves of tomato plants grown in a dust-proof chamber remained unchanged after washing, and their iron content was comparable with that of washed leaves of plants grown in the open glasshouse.

The following experiment was carried out with radioactive iron to determine whether iron was lost from the plant tissues during washing: Tomato plants, var. Market King, were grown from seed in a complete culture solution containing 1 mgm. of iron labelled with 4 μc. of iron-59 per litre. Six, nine and twelve weeks after seed germination the tops were washed, dried and the iron content of the wash solutions and the plants determined by chemical and tracer methods. The results are given in Table 1.

Washing the plant 'tops' for between 30- and 90-sec. periods in detergent and water resulted in a large loss of iron from the external surfaces; but there was no appreciable loss of iron from the plant tissues, as is clearly shown by the low radioactive assay values for iron-59 in the wash solutions. The greater amount of tracer iron in each initial wash may have been caused by abrasion of glandular hairs.

In other experiments the iron content of dried and ground sub-samples of washed leaves were found to be less variable than those of unwashed specimens, suggesting that the unequal distribution of iron contamination on leaf surfaces was the main cause of the variation noted.

It has been suggested that the adsorption of iron on silica and the formation of soluble iron complexes during acid digestion interferes seriously with iron analysis of plants[4]. In our experiments, however, tracer and non-radioactive iron were recovered fully when added at various stages during nitric and perchloric acid digestion of different dried plant materials, which are specially chosen to represent a range of silica contents[5]. Further, in tomato plants containing radioactive iron there was no indication

Table 1. Effect of Washing with Detergent and Water on the Removal of Iron from Tomato Plants

Leaf washing procedure: sequence and duration	(1) μgm. iron leached from plant 'tops', determined by the tracer method	(2) (1) as percentage of total iron in plant 'tops'	(3) μgm. iron in the wash solutions, determined by chemical methods (surface iron)	(4) (3) as percentage of total iron in plant 'tops'
Experiment 1 (6 weeks after germination)				
0·3 per cent Detergent in distilled water (10 sec.)	0·24±0·05	0·2	87	51
Distilled water (10 sec.)	0·10±0·08			
Distilled water (10 sec.)	< 0·01			
Experiment 2 (9 weeks after germination)				
0·3 per cent Detergent in distilled water (20 sec.)	0·37±0·06	0·3	86	33
0·15 per cent Detergent in distilled water (20 sec.)	0·27±0·05			
Distilled water (20 sec.)	0·09±0·06			
Experiment 3 (12 weeks after germination)				
0·3 per cent Detergent in distilled water (30 sec.)	0·68±0·08	0·6	74	31
Distilled water (30 sec.)	0·25±0·07			
Distilled water (30 sec.)	0·17±0·06			

that the iron content of acid digests of plant 'tops' determined chemically by α-α-dipyridyl was less than that determined by the tracer method, thus demonstrating that soluble iron complexes, even should they be formed during acid digestion, did not interfere with the determination of iron in tomato.

A full account of this and related work will appear elsewhere.

D. J. D. Nicholas
C. P. Lloyd-Jones
D. J. Fisher

University of Bristol Research Station,
Long Ashton.
Oct. 25.

[1] Wallace, T., *J. Pomol. and Hort. Sci.*, **7**, 172 (1928).
[2] Nicholas, D. J. D., and Thomas, W. D. E., *Plant and Soil*, **5**, 1, 67 (1953).
[3] Bennett, J. P., *Soil. Sci.*, **60**, 91 (1945). Jacobsen, L., *Plant Phys.*, **20**, 233 (1945). Smith, P. F., Reuther, W., and Specht, A. W., *Plant Phys.*, **25**, 496 (1950). Roach, W. A., Rep. E. Malling Res. Stat., p. 31 (1952).
[4] Mason, A. C., Rep. E. Malling Res. Stat., p. 124 (1950).
[5] Nicholas, D. J. D., *J. Hort. Sci.*, **14**, 2 (1948).

A New Type of Male Fructification referable to *Glossopteris*

In a recent communication[1], I described several types of pollen sac containing typical *Pityosporites* type of pollen from some Raniganj (Upper Permian) coal, Lower Gondwana, India. For some years now, the members of the Lower Gondwana *Pityosporites* have been assumed to be the pollen of *Glossopteris*, because both the genera occur profusely and in close association throughout the system[2]. If such a relationship between *Pityosporites* and *Glossopteris* is acceptable, naturally, therefore, the sacs containing the *Pityosporites* should be regarded as the male fructifications of the *Glossopteris*. If this proposed relationship is established, the morphological value of the male fructifications described here, and in a previous communication[1], may have some bearing in determining the systematic position of *Glossopteris*, since considerable doubt now exists as to the structure of the male fructifications of the genus.

Fig. 1. Photomicrograph showing a dehisced pollen sac liberating numerous Lower Gondwana *Pityosporites* type of pollen grains. × 30

Fig. 2. Photomicrograph showing a pair of characteristic Lower Gondwana *Pityosporites* type of pollen grains on the dehisced wall of the pollen sac shown in Fig. 1. × 260

A new type of sac containing *Pityosporites* type of pollen (Figs. 1–2) from coal of Karharbari stage (Lower Permian) of the Lower Gondwana, India, has now been found. This differs from those previously described[1] in (1) the manner of dehiscence, and (2) its general shape and structure. It is thus a new member of the previously reported group of male fructifications referable to *Glossopteris*.

The new type of pollen sac is free and occurs singly in maceration residues, exannutate, apparently sessile, more or less oval with the base broader than the apical region (which is a very short and slightly raised cylindrical structure), unilocular, dehiscing regularly along a median line of dehiscence from the apex in a longitudinal direction; as a result the sac splits into two equal halves which are attached towards the base and thus liberates typical pollen of *Pityosporites* type (Figs. 1–2). The cell structures of the sac are mostly destroyed; in some places, however, they are faintly visible (but not reproducible photographically). The cells along the line of dehiscence are linear, with mostly irregularly and laterally thickened walls (Fig. 3) where the sac bursts, and the cells become progressively shorter and broader away from the region of dehiscence and thus usually appear as rectangular structures (Fig. 4). The whole pollen sac measures 1,440μ × 1,100μ. A structure of this size can easily be accommodated in the sorus-like body borne by a *Glossopteris*[4].

The pollen grains are typically Lower Gondwana type of *Pityosporites* previously described by many authors. Each grain is provided with two lateral reticulately marked bladders placed on opposite sides of the thickly rimmed, more or less elliptical body, which consists of a number of horizontal stripes

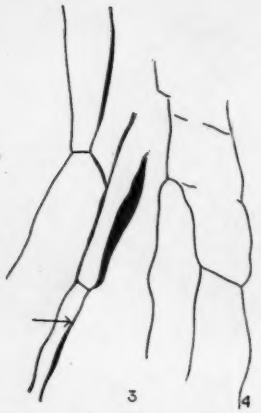


Fig. 3 Camera lucida sketch of some characteristic cells of the line of dehiscence (shown by an arrow head) of the pollen sac with irregular thickening in the walls, mostly restricted towards the actual line of dehiscence. × 425

Fig. 4. Camera lucida sketch of some characteristic cells of the pollen sac wall away from the line of dehiscence. × 425

(Fig. 2). The size varies from 58μ to 80μ (from bladder tip to bladder tip).

Such different types of fructifications—as described here with longitudinal dehiscence, and others previously described[1] with primarily transverse mechanism of dehiscence—do not usually occur in the same genus. However, the tendency towards longitudinal dehiscence as a secondary adaptation for pollen dispersal after the first clear transverse dehiscence is quite clear in some of the pollen sacs described previously[1]. These may be regarded as intermediate forms. It is now time to question whether *Glossopteris*, possibly bearing pollen sacs of characteristically different nature as discussed here and previously[1,4], is a well-knit genus. The ovulate fructifications are also not of the same type[5].

J. Sen

Botanical Laboratory,
University College of Science,
Calcutta.
Oct. 8.

[1] Sen, J., *Proc. Nat. Inst. Sci. Ind.*, **21**B, 48 (1955).
[2] Sen, J., *Proc. Ind. Sci. Congr.*, Pt. 3, 113 (1948). Sen, J., *Bull. Nat. Inst. Sci. Ind.*, **2**, 129 (1953). Ghosh, A. K., and Sen, J., *Trans. Min. Geol. and Met. Inst. Ind.*, **43**, 85 (1948). Virkki, C. (Mrs. Jacob), *Proc. Nat. Acad. Sci. Ind.*, **15**, 93 (1945).
[3] Schopf, J. M., Wilson, L. R., and Bentall, Ray, *Ill. State Geol. Surv. Rept. of Invest.*, No. 91, 27 (1944).
[4] Sen, J., *Nature*, [176, 742 (1955)].
[5] Sen, J., *Bot. Notiser*, **108**. 244 (1955). Plumstead, Edna P., *Trans. Geol. Soc. S. Africa*, **55**, 281 (1952).

Effects of Cyanide on the Roots of *Vicia faba*

Mottram[1] claimed that cyanide ions had a considerable effect on the radiosensitivity of *Vicia faba* as measured by growth-rate reactions. Read[2] was unable to confirm this, and Thoday found (unpublished results) no effect upon chromosome breakage (which is often correlated with growth reactions[3]).

During the course of experimental work designed to investigate this apparent discrepancy, significant effects of cyanide independent of radiation have been discovered. The experiments involved four conditions. Roots were immersed in water or in 5×10^{-4} *M* potassium cyanide at *p*H 7 for 30 min., and at the same time nitrogen or oxygen was bubbled through the vessel. At various intervals after such treatments, the lengths of the roots were measured and tips were fixed for cytological examination.

The measurements of length revealed significant effects of cyanide, primarily in the presence of oxygen. There is a similar effect on the progress of mitosis. Mitotic index (proportion of cells in metaphase, anaphase or telophase) is temporarily reduced after the period in nitrogen, and the reduction may be increased very slightly by cyanide. Oxygen alone produces little effect. Cyanide and oxygen together, however, produce a greater and more prolonged inhibition of mitosis.

Examination of anaphases revealed that the roots treated with cyanide in the presence of oxygen contained a much higher frequency of chromosome aberrations than those that received the other treatments (Table 1). There is no evidence of any effect of oxygen in the absence of cyanide or of cyanide in the absence of oxygen.

Table 1

Treatment		Time elapsing between treatment and fixation (hr.) 1½	3	6	9	10½	12	14	16	24	36	48
Nitrogen + water	Anaphases		100	100	100	100	100	100	100	100		
	% Abnormal		5	1	2	0	1	1	2	0		
Nitrogen + pot. cyanide	Anaphases		100	100	100	100	100	100	100	100		
	% Abnormal		0	4	1	2	0	0	0	0		
Oxygen + water	Anaphases	200	200	200	200		200		200	200	200	200
	% Abnormal	1	0	1	1		1		2	0	1	1
Oxygen + pot. cyanide	Anaphases	200	200	148*	46*		81*		96*	59†	200	200
	% Abnormal	15	23	10	39		26		21	29	14	2

* The low mitotic index at these times reduced the anaphases available below the 100 per root aimed at.
† Only one root examined as in the nitrogen experiments.

Other effects of cyanide have been reported, which may be of interest in considering the present experiments. Cyanide and azide are known to cause mutations[4,5]. It has been suggested that these substances cause the accumulation of peroxides by the inhibition of catalase[5] and that these peroxides may be involved in chromosomal disturbances[6]. It is known that cyanide and azide both inhibit the cytochrome system, and this inhibition may channel more of the aerobic respiration through the cyanide (azide)-insensitive flavoprotein system which can produce hydrogen peroxide[5,7]. Further, King *et al.* suggested that in high oxygen tension the flavoprotein systems have greater activity and more hydrogen peroxide may be formed.

It is possible, therefore, that the chromosome aberrations reported above are caused by peroxide, the formation of which may be partially influenced by oxygen tension.

The relation of cyanide to breakage is, however, complex, for when X-rays are used in conjunction with the other treatments, the effect of cyanide with oxygen disappears. Instead, there is an effect with cyanide in the absence of oxygen. These irradiation results will be the subject of a later report.

This investigation was carried out in Sheffield and was aided by a grant from the Department of Scientific and Industrial Research to one of us (L. J. L.), then in the University of Sheffield Department of Botany.

LORNA J. LILLY
(Leverhulme Fellow)

Department of Botany,
University of Liverpool.

J. M. THODAY

Department of Genetics,
University of Sheffield.
Oct. 26.

[1] Mottram, J. C., *Brit. J. Rad.*, **8**, 643 (1935).
[2] Read, J., Brit. Emp. Cancer Camp., 30th Annual Report, 297 (1952).
[3] Thoday, J. M., *Brit. J. Rad.*, **24**, 572, 622 (1951).
[4] Wagner, R. P., Haddox, C. H., Fuerst, R., and Stone, W. S., *Genetics*, **35**, 237 (1950).
[5] Wyss, O., Clark, J. B., Haas, F., and Stone, W. S., *J. Bact.*, **56**, 51 (1948).
[6] Sparrow, A. H., *Ann. N.Y. Acad. Sci.*, **51**, 1508 (1951).
[7] King, E. D., Schneiderman, H. A., and Sax, K., *Proc. U.S. Nat. Acad. Sci.*, **38**, 34 (1952).

Living and Fossil Pollen from Macquarie Island

THE use of palynology to investigate the ancient floras of antarctic and subantarctic regions and to aid in explaining the present distribution of the living florula has been largely ignored. Auer[1] made use of pollen analysis to describe the fluctuations of forest and steppe vegetation in Tierra del Fuego in postglacial time. Cookson[2] described the pollen occurring in the tertiary lignites of the Kerguelen Archipelago. So far as I am aware, no workers have undertaken similar studies in any other part of this zone.

Macquarie Island (lat. 54° 30′ S., long. 158° 57′ E.), volcanic in origin, dates back to Early Tertiary or Middle Mesozoic time. It has been much reduced in size by block faulting and has undergone extreme glaciation during the last Ice Age. Fluvio-glacial deposits, considered by Mawson[3] to be postglacial in age, are fairly common and include well-developed bands of lignite.

While a member of the 1951 Australian National Antarctic Research Expedition based on Macquarie Island, I was able to obtain a series of lignite samples for examination. By extraction of pollen by the acetolysis method of Erdtman[4] and by comparison of the types discovered with those of the existing vascular flora (some thirty-eight species of grasses and small herbs), it has been possible to show an apparently complete disaffinity between the past and present vascular floras of the island. This finding strongly suggests that the lignites represent the remnants of a preglacial flora. Altogether seventeen main fossil pollen types were found, and it is of interest that these did not include *Nothofagus* or Gymnosperm-type pollens.

During the Ice Age, when the area of land in the vicinity of Macquarie Island was much greater than it is to-day, it is probable that, notwithstanding the severity of the glaciation, parts of the land mass were capable of supporting plant life. Such conditions exist at present in several parts of the subantarctic zone. With the recession of the ice sheet, it is reasonable to assume that the limited plant life began to colonize the freshly exposed land-surface. At the time when faulting and subsidence were practically complete, it is probable that small plant communities were able to survive in more favourable sites on the now much smaller land mass. Those communities may have formed the bands of lignite still preserved at Macquarie Island.

With the land mass greatly reduced in size, a reversal of conditions might readily result in complete extinction of the remnant flora. That such a reversal may have taken place is indicated by the fact that the lignites were found to be covered with considerable layers of fluvio-glacial rubble. Should this explanation be correct, then the fossil pollens may be closely related to the Tertiary floras of the Antarctic.

It is of interest that no definite affinities could be found between the fossil pollens of Macquarie Island and those described by Couper[5] from New Zealand. Although he has recorded compositous grains in deposits ranging from Miocene to Recent in age, without detailed descriptions it is not possible to decide whether any of these are identical with those occurring in the lignites of Macquarie Island.

A search of the available literature[4,6] has shown that the pollen of many species of the antarctic vascular flora has not been described. Until such descriptions become available, the identification of recent fossil pollen from this zone must remain uncertain.

JOHN BUNT

Antarctic Division,
Department of External Affairs,
187 Collins Street,
Melbourne,
Victoria.

[1] Auer, V., *Acta Geogr.*, **5**, 2 (1933).
[2] Cookson, I., *B.A.N.Z. Ant. Res. Exp. Reports*, A, **2**, Part 8 (1947).
[3] Mawson, D., *Aust. Ant. Exp.* (1911–14) *Reports*, A, **5** (1943).
[4] Erdtman, G., "An Introduction to Pollen Analysis" (Chronica Botanica Co., Waltham, Mass., 1943).
[5] Couper, R. A., N.Z. Geol. Survey, Paleont., Bull. 22 (Gov. Printer, Wellington, N.Z., 1953).
[6] Auer, V., Salmi, M., and Salminen, K., *Ann. Acad. Scient. Fenn.*, A, **3** (Helsinki, 1955). Cranwell, L. M., *Bull. Auckland Inst. and Museum*, No. 3 (1953). Erdtman, G., "Pollen Morphology and Plant Taxonomy" (Chronica Botanica Co., Waltham, Mass., 1952). Wodehouse, R. P., "Pollen Grains" (New York and London, 1935).

A Direct Method for the Measurement of Cerebral Blood-flow

THE blood-flow through the rostral and parietal parts of the heparinized cat's brain has been measured by cannulating the sagittal sinus. This flow has been correlated with the systemic blood pressure and the electroencephalogram.

After longitudinal craniotomy in the midline, the sinus was ligated at its caudal end. On the rostral side of the ligature a thin polyethylene catheter was introduced into the sinus. The blood was directed to an electric drop recorder, connected with an 'ordinate recorder' which operated a galvanometer. The blood was then returned to the animal by intravenous drop infusion. The craniotomy interrupted the most

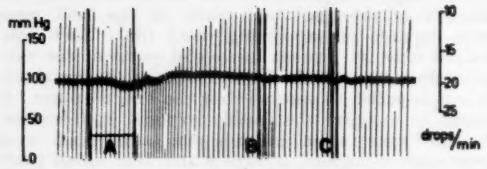


Fig. 1. Cat, 4·5 kgm. 'Nembutal' (40 mgm./kgm.). Vagus, cervical sympathetic trunk and the sinus nerve divided bilaterally. Blood pressure (thick line) from the femoral artery. Blood-flow from sinus sagittalis superior (vertical lines). Each drop of blood from the sinus rapidly carries the spot of the mirror galvanometer to the base of the figure, from which it returns at slower speed so that a steeply rising line is recorded. The length of these lines is directly proportional to time-interval between drops. By joining the upper ends of these lines one obtains a curve inversely proportional to blood-flow (cf. calibration on the right). The record is interrupted every 30 sec. (*A*) 10 per cent carbon dioxide in the inspired air; (*B*) twisting the pinna; (*C*) pinching the paw of the right foreleg. Note, large transient increase of blood-flow in *B*, slower increase in *A*, transient decrease of flow in *C*

important anastomoses between the sagittal sinus and the diploic veins. Ringer solution was injected through the catheter into the sinus in order to show that no larger anastomoses still existed between the sinus and other veins. Intravenous injections of a solution of indian ink and gelatine showed that the drainage was restricted to the rostral and parietal parts of the brain and did not include extra-cerebral areas. Even the jugular bulbs are known to hold only 2·6 per cent extra-cerebral blood[1].

The systemic blood pressure was recorded in the femoral artery by a strain-gauge instrument. The electroencephalogram was led off bipolarly from the middle suprasylvian or the cruciate gyrus.

This method has made it possible to demonstrate that variations in the cortical blood-flow may occur even when the systemic blood pressure is constant. Smaller changes in the blood pressure may be completely without effect on cerebral blood-flow. A larger change in blood pressure, on the other hand, was usually followed by a passive increase in the cerebral blood-flow. The well-known vasodilating effect of an increased concentration of carbon dioxide could easily be demonstrated (Fig. 1,*A*). Cerebral vasomotor reactions, reported to appear during changes in the electrical activity of the cortex[2], were likewise revealed in a very direct fashion. Thus, for example, in the lightly anæsthetized preparation, nociceptive stimuli, twisting the pinna and electrical stimulation of the reticular activating system produced transient changes in the cortical blood-flow. There was a latent period of about 2–5 sec. and a duration which paralleled the concomitant change in the arousal reaction of the electroencephalogram (Fig. 1,*B* and *C*).

Doses of adrenaline and noradrenaline which gave identical rises in the systemic blood pressure were found to produce different effects upon the cerebral blood-flow, the effect of adrenaline being the larger. Ergotamine, in most cases, was found to elicit an increase in the cerebral blood-flow. This effect will be described in detail elsewhere.

Deep anæsthesia abolished all kinds of vasomotor reactions in the cortical vessels. The vascular resistance, which in such circumstances remains constant, makes the cerebral blood-flow a direct function of the systemic blood pressure. Ether paralyses the cerebral vessels in the dilated state, while under barbiturates they are paralysed in a state of constriction. To judge by the electroencephalogram, the resistance of the vessels to anæsthetics corresponds roughly to the level of activity of the cortical neurones.

D. H. Ingvar
U. Söderberg

Nobel Institute for Neurophysiology,
Karolinska Institutet,
Stockholm 60.
Oct. 6.

[1] Shenkin, H. A., Harmel, M. H., and Kety, S. S., *Arch. Neurol. Psychiat.*, **60**, 240 (1948).
[2] Darrow, C. W., Green, J. R., Davis, E. W., and Garol, H. W. *J. Neurophysiol.*, **7**, 217 (1944). Jasper, H. H., and Erickson, T. C., *J. Neurophysiol.*, **4**, 333 (1941). Ingvar, D. H., *Acta physiol. scand.*, **33**, 169 (1955).

Action Potentials from Internal Laryngeal Muscles during Phonation

Electromyography of the internal laryngeal muscles has been applied in the diagnosis of laryngeal palsy by Weddell, Feinstein and Pattle[1]. In a study of phonation, Katsuki[2] recorded action potentials from the m.crico-thyreoideus externus in a case with partial resection of the larynx. In the present study, action potentials were recorded by means of concentric needle electrodes inserted in the m.thyreo-arytaenoideus internus (m.vocalis), crico-thyreoideus externus, inter-arytaenoideus transversus and crico-arytaenoideus posterior (m.posticus) of normal subjects and of patients with laryngeal paresis. In addition,

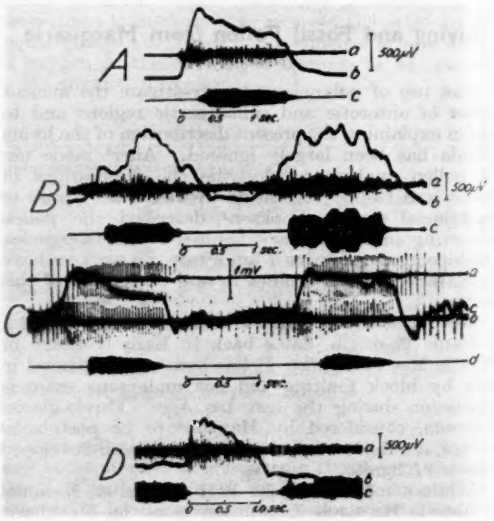


Fig. 1

(*A*) Subject A. H., 64 years; left m.thyreo-arytaenoideus internus, intonation of 'e', frequency 265 c./s. (*a*) Directly recorded action potentials; (*b*) mean action potential amplitude; (*c*) voice recorded on microphone
(*B*) Subject C. S., 55 years; right m.thyreo-arytaenoideus internus, intonation of 'e', frequency 285 c./s.; first with small, then with large intensity. (*a*) Directly recorded action potentials; (*b*) mean action potential amplitude; (*c*) voice recorded on microphone
(*C*) Subject A. J., 44 years; left side paresis of n.recurrens, intonation of 'e', frequency 263 c./s. (*a*) Directly recorded action potentials in left m.crico-thyreoideus externus; (*b*) directly recorded action potentials in left m.thyreo-arytaenoideus internus; (*c*) mean action potential amplitude in left m.thyreo-arytaenoideus internus; (*d*) voice recorded on microphone
(*D*) Subject F. B., 47 years; left crico-arytaenoideus posterior, intonation of 'a', frequency 200 c./s. (*a*) Directly recorded action potentials; (*b*) mean action potential amplitude; (*c*) voice recorded on microphone

the action potential amplitude was averaged electrically and recorded as an expression of the degree of activity. The subject spoke into a condenser microphone, the output of which was amplified and recorded simultaneously with the action potentials.

An increase in activity occurred in the m.thyreo-arytaenoideus internus, crico-thyreoideus externus and inter-arytaenoideus transversus 0·3 sec. before any signal was observed on the microphone (Fig. 1,*A*, *B*,*C*). The degree of muscle activity increased greatly with increasing pitch as long as this obtained without change in register. Increase in tone volume had scarcely any effect on the degree of muscle activity (Fig. 1,*B*). As in other voluntary muscles, the increase in activity was due to an increase in the number of activated muscle fibres and in their frequency of discharge. In cases of laryngeal paresis it was possible to follow the increase in frequency for a single motor unit potential (from 10 to 50 per sec., Fig. 1,*C*). The activity was maximal before and in the very first period of intonation. Then it remained on a slightly lower level until intonation stopped. Activity was simultaneous in the m.thyreo-arytaenoideus internus, crico-thyreoideus externus and inter-arytaenoideus transversus.

The activity in the m.crico-arytaenoideus posterior was greatly inhibited during intonation (Fig. 1,*D*). The inhibition occurred 0·3 sec. before a signal appeared on the microphone.

If the subject was asked to prepare an intonation without voice production ('silent speech'), the initial burst of activity was still observed.

K. Faaborg-Andersen
Fritz Buchthal

Institute of Neurophysiology,
University of Copenhagen.
Sept. 28.

[1] Weddell, G., Feinstein, B., and Pattle, R. E., *Brain*, **67**, 78 (1944). Feinstein, B., *Proc. Roy. Soc. Med.*, **39**, 817 (1945–46).
[2] Katsuki, Y., *Jap. J. Physiol.*, **1**, 29 (1950).

Role of the Terminal Pigment Spots of the Starfish, *Asterias forbesi*, in Light Orientation

It is generally stated in standard reference and text-books of zoology that, in species where such bodies are present, the terminal pigment bodies (or 'eye spots') are necessary for light orientation. In two early studies, Romanes[1], in the "starfish", and Preyer[2], in *Asterina gibbosa* and *Asterias glacialis*, found that these spots were essential in the positive light responses of these starfish and that without these pigment bodies such responses were lacking. On the other hand, several contradictory reports have also appeared[3–5] which emphatically state that positively phototropic responses persist even after the excision of all the eye spots of each ray of *Echinaster crassispina*, *Pentaceros reticulatus* and *Asterias forbesi*. I therefore undertook to check the role of these pigment bodies in light orientation of the common starfish of the North Atlantic coast of North America south of Maine, *A. forbesi*, as well as to establish a possible chemical basis for light perception.

To this end two different sets of study were undertaken; observations were made of the ability of 'eyeless' and intact starfish to orient to light and concomitantly the absorption spectra were studied of extracts of pigments from these terminal bodies as well as from the dorsal skin of individuals of this species.

In the first case, the pigment body was removed from each of the rays of twenty starfish (about one and a half inches across, in size) by simple transverse cutting about one half-centimetre from the tip. These were then placed, together with an equal number of intact starfish of similar size, in a tank with running sea water, which was so illuminated by the light from a 100-watt Burton lamp (placed 18 in. from the end of the tank) that one side of the tank was illuminated by a narrow shaft of light parallel to the long axis of the tank. After all the starfish had been permitted to distribute themselves freely throughout the tank, the number of normal and 'eyeless' animals to be found in the dark zone was counted. After each such observation all the starfish were replaced into the darkened (approximately $\frac{7}{8}$) portion of the tank and allowed to redistribute themselves for at least three (usually 10–12) hours before a subsequent tally was made. The following represents the results of such observations over a six-day period:

Trial No.	Intact starfish in dark zone	'Eyeless' starfish in dark zone
1	10	5
2	15	6
3	11	8
4	9	9
5	6	9
6	19	6
7	6	5

Although facilities for studies involving various portions of the visible light spectrum were not available, a second similar set of observations was made upon 26 eyeless and 26 normal starfish ($1\frac{1}{2}$–2 in. across) exposed to a similar narrow shaft of light from a Westinghouse 60-watt red safety lamp under otherwise identical conditions as above. In one case twelve normal and six eyeless, in a second observation five of each type of starfish were found in the dark part of the tank. Clearly, the eye spots are not essential for positively tropic responses by this species to light of this quality and intensity.

An obvious assumption from the above observations is that the skin of the species in question is sensitive to light. To establish a chemical basis for such sensitivity to light, extracts were prepared, directly as well as indirectly (through phosphate buffer followed by petroleum ether extractions), into a 2 per cent digitonin solution, from the eye spots and adjacent dorsal skin segments from animals of this species, previously dark-adapted in running sea water for at least sixteen hours. All preparations were made in the dark and comminution of tissues effected at 0–5° C. Spectral analyses of such extracts revealed an absorption spectrum with a sharp peak at close to 320 mμ and a secondary, broader and lower plateau at about 460–500 mμ, for each of the sets of extracts studied. Also, a minimum of thirty minutes exposure of each of these extracts to cooled, white light (from a 100-watt Mazda lamp), placed twelve inches from the cuvettes containing these extracts, resulted in a significant decline in the optical density thereof; this indicated the presence of a photosensitive pigment.

Obviously, therefore, both the skin and pigment bodies of this species possess a similar photosensitive chemical component which suggests that both have a common function in gross light perception, especially in the positively phototropic responsiveness of this animal. There remains, however, further clarification

of the role of these pigment bodies in terms of possibly higher sensitivity than those of the dorsal skin to light of the same wave-lengths or in terms of possibly greater (if not specific) sensitivity to particular bands of the spectrum. What is contemplated is an additional behavioural study of the responsiveness of this species to various parts of the spectrum as well as concomitant spectral analyses of the extracted pigments before and after exposure to each of several bands of the light spectrum.

This work was carried out at the Woods Hole Marine Biological Laboratory Department of Physiology Laboratories; I am indebted to Dr. Daniel Mazia for making such facilities available for this study and to Dr. George Wald of Cornell University for his valuable suggestions concerning the chemical aspects of the work.

M. Rockstein
New York University College of Medicine,
550 First Avenue,
New York 16.
Oct. 4.

[1] Romanes, G. J., "Jelly-fish, Star-fish and Sea-urchins" (D. Appleton Co., New York, 1885).
[2] Preyer, W., *Mitteil. aus der Zool. Sta. zu Neapel*, **7**, 191 (1886–7).
[3] Cowles, R. P., *Carnegie Inst. Wash. Papers Tortugas Lab.*, **3**, 95 (1911).
[4] Cowles, R. P., *Johns Hopkins Univ. Circ.*, **232**, 3 (1911).
[5] MacCurdy, H., *Science*, **38**, 98 (1913).

Failure of Enforced Hibernation to inhibit Breeding in the Frog (*Rana temporaria*)

It is well known that the frog (*Rana temporaria*) is extremely tolerant of cold, and may continue to breed when ice covers or encrusts the sides of the ponds. Warmth, or a small transitory rise in temperature, however, may be necessary for breeding to be initiated.

Dr. M. Smith[1] suggests that the variability in time of spawning (apart from temperature) may be due to the phosphate content of the water and to the availability or otherwise of food for the tadpoles. The amount and the intensity of light are also thought to be important.

In view of these accepted facts, it seems worth while recording the following.

A group of male and female frogs, captured in East Anglia in late September 1954, were subjected to enforced hibernation in a domestic refrigerator early in October of the same year.

The thermostat in the refrigerator was set so that the temperature was maintained at 38° F. A maximum and minimum thermometer was put into the refrigerator and the temperature checked twice each day.

The animals were stored in a shallow enamel tray containing 1½ in. of tap water and covered by a piece of hardboard drilled with several ½-in. holes. The water in the tray was changed on alternate days. There was no pilot light in this particular refrigerator.

In mid-May 1955, 7½ months after enforced hibernation had started, amplexus occurred in four pairs of animals and spawn was laid.

Spawn continued to be laid at intervals until early July. During this time, however, the animals were not always in amplexus. The spawn was removed from the refrigerator and put into shallow trays; some contained tap water and one contained rain water. The spawn in the rain water developed and the spawn in the tap water did not. By August 1955 the froglets from this spawn were approximately 1½ cm. long and beginning to take adult frog laboratory food.

When the adult frogs spawned it is estimated that they had been exposed to light of average indoor intensity for half a minute on alternate days for 7½ months, and warmth for the same period. They had, however, been exposed to cold tap water also on alternate days. Due to the large surface area, the water would probably only take 15–30 min. to attain the temperature of the refrigerator, that is, 38° F. It is probable that the phosphate content of the water varied little, and certainly there was no food available either for the adult frogs or for any potential tadpoles. It is noteworthy that not all the female animals spawned, and that the onset of breeding was substantially delayed in the others.

It is possible, and indeed probable, that there was a gradual build-up of the hormones necessary for breeding to occur; but it must be generally agreed that the external stimuli usually considered necessary for this to occur were minimal.

Rhoda M. Allison
17 Cumberland Court,
Cardigan Road,
Leeds 6. Oct. 9.

[1] Smith, M., "The British Amphibia and Reptiles", p. 129 (1951).

Status of *Protobatrachus massinoti*

The history of the Amphibia Salientia can readily be traced back to the Jurassic when it appears that, skeletally at least, they were already typical, modern Anura. The pre-Jurassic history of frogs, however, was completely unknown until 1937 when Piveteau[1] described *Protobatrachus massinoti* from the lower Trias of Madagascar. To accommodate *Protobatrachus*, Piveteau defined a new order, the Proanura, differing from the Anura chiefly in possessing a tail but no urostyle and with the tibia and fibula, radius and ulna, unfused.

In excluding *Protobatrachus* from the Anura, Piveteau strongly emphasized that no analogy exists between the tail of modern frog tadpoles and the 'true' tail of *Protobatrachus* since, in the former, no vertebræ develop but only the notochord with its sheaths and enveloping skeletogenous layer. In a recent survey of anuran larvæ, however, I have examined tadpoles of the pelobatid *Megophrys major* and found that, from early larval stage, they possess about seventeen ossified caudal vertebræ—a condition that, so far as I am aware, has not hitherto been described for any other anuran larva. In the light of this discovery it seemed pertinent to re-examine Piveteau's statement and the status of *Protobatrachus*.

If *Protobatrachus* is regarded as an adult form two problems of functional morphology are posed. First, the animal possesses ilia, femora, tibiæ and fibulæ which, although relatively not as elongated as in the adults of modern frogs, are, nevertheless, clearly salientian adaptations and, consequently, a sacral articulation would be expected. But no sacrum appears to be present. Two vertebræ with backwardly directed ribs lie between the iliac arms, but they are quite free of the pelvic girdle; while, mesial to the heads of the ilia, where articulation normally occurs, the single vertebra present is unexpanded and unspecialized. How, then, can the salientian trends so clearly shown in the hind limbs and girdle, and which are so essentially concerned with transmission of

thrust against the vertebral column, be correlated with the absence of a functional sacrum? Secondly, as Piveteau appreciated, and as the nature of the caudal vertebræ suggests, the tail was much longer than the remains described by him. How can such an organ, so clearly incompatible with the salientian features listed above, be considered to have combined with them to form an efficient locomotory system?

These morphological enigmata can logically be resolved by regarding *Protobatrachus* as a tadpole in the later stages of metamorphosis. The tail with its ossified vertebræ is now explicable as a larval, locomotory organ destined for resorption at metamorphosis as in the case of *Megophrys major*. This view can also account for the moderate lengths of the ilia and hind limb bones and for the absence of a sacrum, for these elements complete their development and are knit into a functional unit only towards the end of metamorphosis when, after the resorption of the tail, they form the locomotory organ of the adult. It may explain, too, the paucity of the anterior cranial elements for, at this stage, they would not be ossified to any degree.

A detailed account of the structure and development of the vertebral elements in *Megophrys major*, with a discussion on anuran phylogeny, will be published elsewhere.

I. Griffiths

Department of Zoology,
Birkbeck College,
London, W.C.1. Oct. 18.

[1] Piveteau, J., *Ann. Paleontol.*, **34**, 135 (1937).

Effect of Supplementary Choline and Methionine on the Response of Chickens to Folic Acid

The wide range of folic acid requirements of chickens reported by various authors[1] is partly explained by considerations of dietary and genetic factors known to affect requirements. Excess intake of choline[2] and glycine[3] has been shown to depress growth or produce anæmias which can be prevented by feeding supplementary folic acid. In experiments at this Station, the effect of choline on folic acid requirements has been confirmed, and supplementary methionine has been shown to have a similar effect.

Two experiments, observing the effect of supplements of 0·2 per cent *dl*-methionine and 0·066 per cent choline (providing an equivalent quantity of labile methyl groups as 0·2 per cent methionine) on the response to supplementary folic acid, have been completed using White Leghorn chickens up to six weeks old. The basal diet contained crushed wheat, meatmeal and whey powder. Dietary supplements and results are summarized in Table 1.

The response to methionine added as the sole supplement or together with folic acid in experiment 1, and in the presence of both choline and folic acid in experiment 2, shows that the diet was deficient in methionine and that the response was independent of the role of methionine as a methyl donor.

In experiment 1, the absence of response to folic acid alone, and the response following addition of folic acid to the diet supplemented with methionine, indicate that the chicken's requirements of folic acid were higher following methionine supplementation. In experiment 2, the growth depression following supplementation of the diet with choline and the effect of addition of folic acid in reversing this response suggest that the methionine – folic acid interaction observed in the first experiment was due to the labile methyl group in the molecule. These results indicate that folic acid is required for the catabolism of excess methyl groups as well as in transmethylation processes. As glycine also provides labile methyl groups[3], the effect of folic acid in reversing the toxicity of glycine further confirms this role of the vitamin.

Table 1. Effect of Methionine and Choline Supplements on the Growth Response of Chickens to a Folic Acid Supplement

	Supplements to basal diets			
Exp. 1	Nil	4·4 p.p.m. folic acid	0·2% *dl*-methionine	4·4 p.p.m. folic acid + 0·2% *dl*-methionine
Relative weights at 6 weeks (difference for significance $P <$ 0·05, 5 per cent)	100	98	112	120

	Supplements to basal diets			
Exp. 2	Nil	0·066% choline	0·066% choline + 4·4 p.p.m. folic acid	0·066% choline + 4·4 p.p.m. folic acid + 0·2% methionine
Relative weights at 6 weeks (difference for significance $P <$ 0·05, 5 per cent)	100	83	101	106

Further details of these experiments will be published elsewhere.

M. W. McDonald

Poultry Experiment Station,
Seven Hills,
New South Wales.

[1] Duckworth, J., and Ellinger, G. M., *Brit. J. Nutr.*, **3**, 253 (1949).
[2] Melas, V. H., Pearson, P. B., and Sherwood, R. M., *Proc. Soc. Exp. Biol. Med.*, **62**, 174 (1946). Davis, J. E., *Amer. J. Physiol.*, **142**, 402 (1944); **147**, 404 (1947).
[3] Nabel, E. C., Sunde, M. L., Cravens, W. W., and Snell, E. E., *Poultry Sci.*, **30**, 925 (1951). Macklin, J. J., Denton, C. A., and Bird, H. R., *J. Nutr.*, **46**, 389 (1952).
[4] Arnstein, H. R. V., and Neuberger, A., *Biochem. J.*, **55**, 259 (1953).

Science Babel

While agreeing with the points made in the editorials of November 5 and 19, I may perhaps say that you reveal more than I think you were aware of when writing "a nation using . . . a minority language cannot escape bilingualism if it desires to attain high standards of culture and scholarship". If the sentence is understood as referring to the use of minor languages for publishing, it is indisputable; but all too frequently it turns the other way—scholars within the major language groups neglecting the literature outside their own language. In fact, if we take into consideration languages read as well as written, no language group can to-day avoid even trilingualism if it wishes to attain the highest standards of culture and scholarship.

To illustrate this point I have made a small survey of world scientific literature within a comparatively narrow field, so that the authors have had the theoretical possibility of drawing from the same, rather well-circumscribed scientific heritage. Two botanical journals were used from each country or group of countries[1], one with a background of ecology, the other more general. The most recent issue(s) was (were) used, and at least ten papers were analysed. No issue was older than 1952.

The idea was that, whereas it is difficult to calculate how much scientific material is presented in different languages, it is comparatively easy, by studying the reference lists at the ends of the papers, to find out what is really utilized by fellow scientists.

Table 1

Country	No. of papers	No. of titles in reference lists	Percentages								
			English	German	French	Russian	Scandinavian (coll.)	S. European (coll.)	Latin	Dutch	Others
Britain	39	618	78	15	3	–	3	–	–	1	–
France	22	1,000	42	14	42	--	+	1	1	–	+
Germany	26	413	22	69	7	½	½		–	+	–
Scandinavia	25*	554	63	19	4	1	10	½	2½	–	–
Switzerland	30†	701	24	60	13	–	1	+	2	+	–
United States	38	679	84	11	4	–	+	+	–	+	?
U.S.S.R.	33	392	16	10	1	73	+	–	–	–	–

* 23 English, 1 German, 1 Swedish.
† 29 German, 1 French.

The results are given in Table 1. Its shortcomings are obvious, but the fact that the percentage figures from each pair of journals (from one country or area) were practically identical, may serve to give it more emphasis. The only exception was the Swiss pair, which showed considerable discrepancies.

That our Soviet colleagues know more about 'Western' literature than the reverse is nothing new; but it is deplorable. New to many others besides myself may be the high standard of polyglottism exhibited by the French literature. That the English and even more the American literature should emerge as the narrowest is scarcely unexpected, but it should be remembered that in this case the 'home' language is undoubtedly also the dominating one within the pool, which accounts for a double effect (one of the Swiss journals also had 80 per cent 'home' language).

The main lesson to be learnt from the table is what a waste it is to publish in anything but the three great languages (and even the inclusion of French among them may be questioned). There is to-day the possibility of publishing primary scientific material in a large number of different languages; but there is also the overwhelming possibility that anything published in a minor language will pass unrecognized and never enter the common pool of world scientific knowledge.

Because I have more than twenty years experience in publishing scientific material in two languages not my own, I think I may safely protest against the accusation that compulsion to write in a foreign language curtails the possibilities for intelligent communication. Admitting that there are exceptional brains, for which no rule can be laid down, I am convinced that a brain that has the capacity for scientific work has also the capacity to learn so much of at least one foreign language as to be able adequately to express scientific ideas in it.

It is a waste, and it is also inconsiderate, to publish primary scientific material in a minor language. Notwithstanding the fact that important works have been published in other languages, it is a fact that the great majority of those papers that are worth reading have been published in the three major languages—and in some branches of science also in Latin. Very few are born to more than one of these languages, the other ones have to be acquired: so far as reading goes, the difference between members of the great and small language groups is the difference between learning two or three foreign languages sufficiently well to use them. That is theory; I fear that practice may differ. The learning of a foreign language, even if it is not as formidable a task as some persons seem to consider, certainly does demand an intellectual effort, and one cannot expect anybody but the very few to be willing to take up more than the two or three essential ones. It is interesting to note, however, from the table that the question whether two or three Western main languages must be learnt does not seem to upset the tendency to learn other languages besides. It may be that very much excellent science is at present published in other languages; but as long as these languages are, and cannot but be, inaccessible to the majority of those who would otherwise have been potential readers, this body of knowledge does not exist to all intents and purposes.

Those who belong to a major language, and who perhaps have, or perhaps have not, taken the trouble to acquire a reading knowledge of two other languages, should show indulgence towards those who have been obliged to learn enough of a third one to be able to write it—which is something quite different. I have a personal reason for this appeal. Some years ago I, together with a Danish colleague, published a book (170 pages) in English, which was reviewed in *Nature*[2]. It was a very kind review, but the reviewer expressed his regrets that the English (which had, incidentally, been checked by two English colleagues) was not good enough. At my request the reviewer very kindly furnished me with a list of his grievances. They were, in all, twenty-eight, of which seven were misprints, two referred to a Latin word, one was rejected for being American, and four were new words we had to construct because no such word existed in English—they were all misunderstood, perhaps they were badly constructed. Three cases were disputable (usage accepted by the Concise Oxford Dictionary), and there remained eleven cases of more or less awkward usage. No expression was so awkward that it interfered with intelligibility.

I mention this at some length, not to give vent to any personal feelings against a deceased colleague, but because it is an excellent example of what should not be done. Nothing could be better calculated to scare people away from using the great languages than just this kind of purism. It may be maintained that French purism has destroyed French as a universal language. If English is to go the same way, the outlook for future scientists is very gloomy indeed.

Knut Fægri

Botanical Museum,
University of Bergen.

[1] Britain: *J. Ecol.*; *New Phytol.* France: *Ann. Sci. Nat., Série Botanique*; *Rev. générale de Botanique.* Germany: *Ber. deutschen bot. Gesell.*; *Planta.* Scandinavia: *Bot. Notiser*; *Oikos.* Switzerland: *Ber. schweiz. Bot. Gesell.*; *Jahrberichi geobot. Forschungsinstitutes Rübel in Zürich.* United States: *Ecol.*; *Amer. J. Bot.* (In American literature there was one reference from the Quran and one from Talmud, but I doubt if they were in the original language.) U.S.S.R.: *Bull. Main Botanical Garden in Moscow*; *Botanicheskii J.*

[2] Fægri, Knut, and Iversen, Johs, "Text-book of Modern Pollen Analysis" (Munksgaard, Copenhagen, 1950) (*Nature*, **168**, 309; 1951).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, February 20

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE (in the Lecture Theatre of the Science Museum, South Kensington, London, S.W.7), at 5.30 p.m.—Prof. Gordon Manley: "Contributions to Instrumental Meteorology before 1800".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Informal evening on "Ultrasonics in Industry". Talk by Mr. C. F. Brocklesby (with films and demonstrations).

SOCIETY OF CHEMICAL INDUSTRY, PESTICIDES GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. J. Carmichael: "Recent Advances in the Use of Insecticides in Animal Health".

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. W. C. Price: "Spectroscopy in Science and Technology" (Inaugural Lecture).*

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY (at the University, Manchester), at 5.45 p.m.—Prof. Clifford Holliday: "Anuradhapura, Sacred City of Ceylon" (Percival Lecture).

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Dr. D. J. Crisp: "The Changing Climate of Northern Europe".

Tuesday, February 21

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (in the Large Chemistry Lecture Theatre, Royal College of Science (Imperial College), Imperial Institute Road, London, S.W.7), at 10.30 a.m.—Symposium on "Some Cultural and Chemical Aspects of Crop Production".

UNIVERSITY COLLEGE, LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. Kathleen Lonsdale, F.R.S.: "Crystals, Temporary and Permanent: (1) Ice".*

SCIENTIFIC FILM ASSOCIATION (in the Mezzanine Cinema, Shell-Mex House, Strand, London, W.C.2), at 6.30 p.m.—Mr. A. J. Speakman: "The Film and Work Study".

OIL AND COLOUR CHEMISTS' ASSOCIATION (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. H. T. Bone: "Instrumentation and Automatic Control with Applications to Resin and Varnish Manufacture".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. R. C. McIntyre: "Design of Low Landing Speed Aircraft".

Wednesday, February 22

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. W. F. Bewley: "The British Glasshouse Industry".

PHYSICAL SOCIETY, COLOUR GROUP (at the Institute of Ophthalmology, Judd Street, London, W.C.1), at 3.30 p.m.—Mr. G. J. Chamberlin: "Kippers, Cocktails, Confectionery and Colour"; 5.15 p.m.—Prof. M. Richter (Berlin): "Colorimetric Work in Germany".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. L. C. King: "A Geomorphological Comparison between Eastern Brazil and Africa" (to be read by Dr. F. Dixey); Mr. C. Downie: "Microplankton from the Kimmeridge Clay".

SOCIETY OF CHEMICAL INDUSTRY (joint meeting of the FOOD and CORROSION GROUPS, at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Meeting on "Control of Corrosion in the Dairy Industry".

Thursday, February 23

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. C. H. Gallagher, Mr. J. D. Judah and Mr. K. R. Rees: "The Biochemistry of Copper Deficiency. 1: Enzymological Disturbances, Blood Chemistry and Excretion of Amino Acids. 2: Synthetic Processes"; Mr. J. Green: "Variation in the Hæmoglobin Content of *Daphnia*".

INSTITUTE OF REFRIGERATION (at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Mr. H. Burley and Mr. E. J. Perry: "Modern Trends in Dairy Refrigeration".

PHYSICAL SOCIETY, ACOUSTICS GROUP (at the National Hospital, Queen Square, London, W.C.1), at 5.30 p.m.—Dr. D. E. Broadbent: "Physiological and Psychological Effects of Noise".

Friday, February 24

INSTITUTE OF METALS (at the University, Edgbaston, Birmingham 15), at 10.30 a.m.—Informal Discussion on "Furnace Refractories for the Use of the Non-Ferrous Metal Industries".

INSTITUTION OF MECHANICAL ENGINEERS, INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 2.30 and 5.30 p.m.—Discussion on "The Productivity Report on Industrial Engineering".

FIELD STUDIES COUNCIL (at Goldsmiths' Hall, Foster Lane, London, E.C.2), at 4.30 p.m.—Annual General Meeting. Prof. S. W. Wooldridge: "On Understanding a Piece of Country".

INSTITUTION OF ELECTRICAL ENGINEERS, SUPPLY SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. F. Bianchi di Castelblanco: "The Crossing of the Messina Straits with 230-kV. Double-Circuit Overhead Transmission Line".

ROYAL INSTITUTE OF CHEMISTRY (at Norwood Technical College, Knights Hill, West Norwood), at 7 p.m.—Dr. J. B. Firth: "The Chemist in the Detection of Crime".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Mr. N. Tinbergen: "The Activation, Extinction and Interaction of Instinctive Urges".

Saturday, February 25

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Dr. Marian W. Smith: "The Swaixwe—a Social Dance of the American Indians of the Pacific Coast".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SECRETARY (graduate, preferably between the ages of 35 and 45, with a general knowledge of the content, organization and administration of technical education in this country, and preferably with experience in industry)—The Acting Secretary, National Council for Technological Awards, Ministry of Education, Curzon Street, London, W.1 (February 22).

ASSISTANT EXPERIMENTAL OFFICER (with G.C.E. advanced level in chemistry or biology and one other science subject and an interest in biochemistry; if over 22 a pass degree, higher national certificate or equivalent) in the Department of Scientific and Industrial Research, Food Investigation Low Temperature Research Station, Cambridge, to assist in studying the chemistry and microbiology of spoilage in poultry—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting G.29/6A (February 25).

SENIOR LECTURER (with a good honours degree, together with teaching experience, and preferably with industrial or research experience) IN INORGANIC CHEMISTRY at the City College of Technology, Liverpool—Director of Education, 14 Sir Thomas Street, Liverpool 1 (February 25).

LECTURER IN ORGANIC CHEMISTRY—The Principal, Royal Holloway College, Englefield Green, Surrey (February 27).

SENIOR RESEARCH FELLOW (with an honours B.Sc. degree in chemistry or biochemistry and research experience) IN THE DEPARTMENT OF BIOLOGICAL CHEMISTRY—The Secretary, The University, Aberdeen (February 29).

ASSISTANT BACTERIOLOGIST (science graduate) in the Regional Bacteriological Laboratory, Raigmore Hospital, Inverness—Secretary and Administrative Medical Officer, Office of the Northern Regional Hospital Board, Raigmore, Inverness (March 3).

ASSISTANT LECTURER or DEMONSTRATOR IN PATHOLOGY—The Registrar, The University, Manchester 13 (March 3).

ASSISTANT LECTURER (with special qualifications in applied mathematics) IN MATHEMATICS—The Registrar, The University, Manchester 13 (March 3).

DEPUTY LIBRARIAN—The Registrar, The University, Sheffield (March 3).

LECTURER (preferably with a higher degree) IN PHYSICS—The Registrar, King's College, Strand, London, W.C.2 (March 9).

SIMSON CHAIR OF MATHEMATICS—Secretary of University Court, The University, Glasgow (March 9).

LECTURER or ASSISTANT LECTURER IN MATHEMATICAL STATISTICS—The Registrar, The University, Manchester (March 10).

RESEARCH ASSISTANT (with a degree in biology or a closely allied subject, and preferably with experience in histology) IN THE DEPARTMENT OF BIOMECHANICS AND SURGICAL MATERIALS at the Country Section, Royal National Orthopaedic Hospital, Stanmore, Middlesex—The Dean, Institute of Orthopaedics, 234 Great Portland Street, London, W.1 (March 10).

PROFESSOR OF TEXTILE TECHNOLOGY in the University Alagappa Chettiar College of Technology, Guindy—The Registrar, University of Madras, Madras 5, India (March 12).

CHAIR OF PHYSICS—The Secretary, The University, Exeter (March 15).

CHEMISTS (3) (with a good honours degree in chemistry, and for one of the posts at least 2–3 years research experience in organic chemistry) for work in a new research group being established in the University of Exeter for investigations of chemistry of tobacco smoke, with particular reference to its possible influence on incidence of cancer of the lung—The Vice-Chancellor, The University, Exeter (March 15).

AIR POLLUTION ENGINEER (with a university degree in chemical technology or equivalent qualification and about twelve years experience in chemical engineering or allied activities) in the City Engineer's Department, Durban—Messrs. Webster, Steel and Co., 3 St. Helen's Place, Bishopsgate, London, E.C.3 (March 16).

CHAIR OF PREHISTORIC EUROPEAN ARCHÆOLOGY at the Institute of Archæology—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 21).

CHAIR OF VETERINARY MEDICINE—The Registrar and Secretary, The University, Bristol (March 23).

CHAIR OF PHILOSOPHY—The Registrar, University College, Leicester (March 24).

CHAIR OF PHYSICAL CHEMISTRY at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, March 26).

HEAD (with high academic qualifications, considerable research experience and established administrative ability) OF THE BOTANICAL DIVISION of the Rubber Research Institute of Malaya, Kuala Lumpur—The Secretary, London Advisory Committee for Rubber Research (Ceylon and Malaya), Imperial Institute, London, S.W.7 (March 26).

DIRECTOR (with proved high scientific attainments, preferably in fields related to soils or crops, combined with administrative experience either as head or deputy in the organization and running of a research institute or university department) OF THE COCONUT RESEARCH INSTITUTE OF CEYLON—The Chairman, Coconut Research Board, Department of Agriculture, Peradeniya, Ceylon (March 31).

LECTURER (with a degree in mining engineering, or equivalent, from a university or university school of mines, and either operating or research experience in ore or mineral dressing) IN MINING ENGINEERING at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, March 31).

SENIOR LECTURER (with a higher degree in psychology) IN PSYCHOLOGY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, March 31).

ASSISTANT CONSERVATOR (with a university degree in forestry) OF FORESTS in Sierra Leone—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD.61/15/04.

ASSISTANT LECTURER IN SOCIAL ANTHROPOLOGY—The Secretary, London School of Economics and Political Science, Houghton Street, London, W.C.2.

BIOCHEMIST in the newly equipped Clinical Research Laboratory—The House Governor, Royal Marsden Hospital, Fulham Road, London, S.W.3.

CHIEF MATERIALS ASSISTANT (under 40, with a wide experience of laboratory work on soils, bitumen, concrete and other building materials, and preferably with a B.Sc. degree or H.N.C. or other similar qualification in physics or engineering) in the Public Works Department, Kenya, to check and control all test results reported by soils, bitumen and building material laboratories, under the direction of the Chief Materials Engineer—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.112/7/036/C1.

LECTURER IN BOTANY (Assistant Grade B)—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

MASTER TO TEACH PHYSICS at least to advanced level together with some Mathematics—The Head Master, Westminster School, 17 Dean's Yard, London, S.W.1.

MEDICAL PHYSICIST (preferably with previous experience)—Group Secretary, War Memorial Hospital, Scunthorpe.

OPERATIONAL RESEARCH OFFICER (with a good university degree in mathematics, science, engineering or economics, and previous operational research experience) to study factors effecting productive efficiency throughout the Corporation—Head Office Personnel Officer, British European Airways, Keyline House, Ruislip, Middlesex.

PHYSICAL CHEMIST (with a first- or second-class honours degree or equivalent qualification in chemistry) at a Ministry of Supply Research and Development Establishment, Waltham Abbey, Essex, to study rheological properties of solid systems based on visco-elastic polymers and to assist in formulation of such polymers—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.77/6A/AA.

RESEARCH ASSISTANT (female, with a degree in chemistry and an interest in the physical chemistry of biological systems)—The Secretary, Research Institute (Animal Virus Diseases), Pirbright, Surrey.

RESEARCH PHYSICIST (with a good honours degree) to assist in research into the fundamental principles underlying the processing of textile fibres into yarns—The Secretary, The British Jute Trade Research Association, Kinnoull Road, Kingsway West, Dundee.

SENIOR LECTURER (with an honours degree in mathematics, and preferably with research experience) IN MATHEMATICS—The Principal, West Ham College of Technology, Romford Road, Stratford, London, E.15.

SENIOR LECTURER (with experience in some field of applied physics (for example: electronics, solid state physics, vacuum technology, applied heat)) IN THE PHYSICS DEPARTMENT—The Secretary, Northampton Polytechnic, St. John Street, London, E.C.1.

TECHNICAL ASSISTANT (with a pass degree or equivalent in chemistry, biochemistry or physiology) to assist in biochemical research into certain aspects of diabetes—Professor of Physiology, The Medical School, King's College, Newcastle-upon-Tyne 1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

British Cast Iron Research Association. Services to the Iron-founding Industry. Pp. 20. (Alvechurch, Birmingham: British Cast Iron Research Association, 1955.) [612

Scottish Home Department. Freshwater and Salmon Fisheries Research Series. No. 9: A Review of the Literature on the Biology of the Atlantic Salmon (*Salmo salar* Linn). By K. A. Pyefinch. Pp. 24. (Edinburgh: H.M. Stationery Office, 1955.) 4*s*. net. [612

Memoirs of the Geological Survey of Great Britain. Palaeontology, Vol. 4, Part 1: Fossil Plants of the Carboniferous Rocks of Great Britain (Second Section). By Dr. Robert Crookall. Pp. iv+84+24 plates. (London: H.M. Stationery Office, 1955.) 60*s*. net. [612

Aero Research Technical Notes. Bulletin No. 154: Structural Features of the Fokker "Friendship." Pp. 6. Index to Bulletins 60–144. Pp. 8. (Duxford: Aero Research Limited, 1955.) [1312

Bulletins of Marine Ecology. (Formerly Hull Bulletins of Marine Ecology.) Vol. 4, Nos. 29 and 30: Continuous Plankton Records—The Decapod Larvae in the North Sea, 1950–51. By Dr. C. B. Rees. List of Records, 1953–54. By K. M. Rae. Pp. 69–84+plates 13–18. (Edinburgh: Scottish Marine Biological Association, 1955.) 10*s*. [1312

Building Research Station Digest. No. 82 (November, 1955). Building Mastics. Bonding New Concrete to Old. Pp. 5. (London: H.M. Stationery Office, 1955.) 3*d*. [1312

Society for the Promotion of Nature Reserves. Handbook, 1955. Pp. 60+3 plates. (London: Society for the Promotion of Nature Reserves, c/o British Museum (Natural History), 1955.) 5*s*. [1312

British Electrical and Allied Industries Research Association. Technical Report L/T317: On the Thermal Excitation of Trapped Electrons in Ionic Solids. By J. H. Simpson. Pp. 18+3 figures. 12*s*. 6*d*. Technical Report L/T318: Gas Temperature in Argon Spark Channels. By R. D. Craig. Pp. 4. 6*s*. (Leatherhead: British Electrical and Allied Industries Research Association, 1954.) [1312

Forestry Commission. Report on Forest Research for the year ending March, 1954. Pp. vi+177+8 plates. (London: H.M. Stationery Office, 1955.) 6*s*. net. [1312

Other Countries

New Zealand Society of Soil Science. The Role of Soil Science in New Zealand Problems. By N. H. Taylor. (First Presidential Address.) Pp. 12. 1*s*. (Reprinted from *Trans. Roy. Soc. N.Z.*, 82: 961–71, 1955.) Proceedings of the First Conference. (Held as Section M of the Eighth New Zealand Science Congress, Auckland, May 17th to 21st, 1954.) Pp. 32. 4*s*. (Wellington: New Zealand Society of Soil Science, 1955.) [612

New Zealand: Department of Scientific and Industrial Research. Geophysics Division. Geophysical Memoir 3: Aeromagnetic Surveys in New Zealand, 1949–1952. By V. B. Gerard and J. A. Lawrie. Pp. 20+6 maps and 3 Profile Sheets. Amberley Observatory. Magnetic Results for 1953. Pp. v+53. (Wellington: Government Printer, 1955.) [612

Building Research in Canada, Vol. 2, No. 1 (30 June, 1955). (A Progress Report of the Division of Building Research.) Pp. 32. (Ottawa: National Research Council, 1955.) [612

International Union of Testing and Research Laboratories for Materials and Structures (RILEM). Proceedings of the International Symposium on Nondestructive Testing of Materials and Structures. Vol. 1: Pp. x+1–208. Vol. 2: Pp. ii+209–404. (Paris: International Union of Testing and Research Laboratories for Materials and Structures.) 2000 francs. [612

Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture. Comptes Rendus de Recherches. No. 16 (Novembre, 1955): Travaux de la Commission de Recherches pour l'Étude des tuyanteries à vapeur (Première Partie). Pp. 84. (Bruxelles: Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture, 1955.) 95 francs. [612

Institut Royal Météorologique de Belgique. Bulletin de la Station Ionosphérique de Lwiro—Congo Belge, de l'Institut pour la Recherche Scientifique en Afrique Centrale (IRSAC). Vol. 1: Février 1952 à Juillet 1953. Pp. 216. (Uccle, Bruxelles: Institut Royal Météorologique de Belgique, 1955.) [612

Sudan Government. Wellcome Chemical Laboratories, Medical Services, Ministry of Health. Annual Report of the Government Analyst for the year 1954–55. Pp. 16. (Khartoum: Ministry of Health, 1955.) [1312

Administration Report of the Director of National Museums, Ceylon, for 1954. Pp. 21+2 plates. (Colombo: Government Publications Bureau, 1955.) 75 cents. [1312

Bulletin of the American Museum of Natural History. Vol. 107 Article 2: Marine Molluscs Collected during the *Askoy* Expedition to Panama, Colombia, and Equador in 1941. By Leo George Hertlein and A. M. Strong. Pp. 159–318+plates 1–3. (New York: American Museum of Natural History, 1955.) 2 dollars. [1312

Commonwealth of Australia. Commonwealth Scientific and Industrial Research Organization. Seventh Annual Report for the year ending 30th June, 1955. Pp. 265. (East Melbourne: Commonwealth Scientific and Industrial Research Organization, 1955.) [1312

West African Maize Rust Research Unit. First Annual Report, 1953. Pp. 48. (Ibadan: West African Maize Rust Research Unit; London: Crown Agents for Oversea Governments and Administrations, 1954.) 9*d*. [1312

Tanganyika. Records of the Geological Survey of Tanganyika. Vol. 2, 1952. Pp. ii+66+10 plates. (Dar-es-Salaam: Government Printer, 1955.) Shs. 7.50. [1312

Northern Rhodesia. Department of Geological Survey. Bulletin No. 2: The Geology and Mineral Resources of the Big Concession Mumbwa District. By R. T. Brandt. Pp. 56+4 plates+1 geological map. (Lusaka: Government Printer, 1955.) 14*s*. [1312

Annals of the New York Academy of Sciences. Vol. 61, Article 4: Biology of Poliomyelitis. By Karl Habel and 53 other Authors. Pp. 737–1064. 5 dollars. Vol. 63, Article 2: Nutrition in Infections. By W. A. Wright and 26 other Authors. Pp. 145–318. 4 dollars. Vol. 63, Article 3: Psychotherapy and Counseling. By L. K. Frank and 16 other Authors. Pp. 319–432. 3.50 dollars. (New York: New York Academy of Sciences, 1955.) [1312

Editorial and Publishing Offices of "NATURE"

MACMILLAN & CO., LTD.,

ST. MARTIN'S STREET, LONDON, W.C.2.

Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £6, payable in advance, postage paid to any part of the world

Advertisements only should be addressed to

T. G. Scott & Son, Ltd., Crown House, 143–147 Regent Street, London, W.1

Telephone Number: Regent 3891

All rights reserved. Registered as a newspaper at the General Post Office